Nebraska Department of Agriculture Specialty Crop Block Grant Program Final Performance Reports (FY 2009 – Farm Bill)

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Project Title

Increasing the Number of Nebraska Young Adults Involved in the Production and Selling of Locally-Grown Fruits and Vegetables

Project Summary

Consumer demand for fresh produce is evident across Nebraska and farmers' markets provide an important avenue with which to meet this demand. Increased purchases of locally grown agricultural products create viable markets for Nebraska's produce farmers, which add to rural economic sustainability. However, many of the farmers involved in the production and selling of produce are older adults and the number of young famers involved in this sector of agriculture is lacking. The out migration of youth from rural communities is of concern to rural viability. Upon graduation from post-secondary education, a growing number of young, educated adults are not returning to their hometown to run their family farming operation. Instead, they are seeking employment in other parts of the nation that provides them with new opportunities and benefits that are more applicable to their areas of study and career paths. These factors play into the realization that our youth are becoming disconnected from the agricultural industry and the foods they eat. Additionally, the increase in the number of beginning farmers in Nebraska is sluggish, and, in some years, stagnant. Therefore, the purpose of this two-year project was to bridge this gap by working with six Nebraska FFA Chapters to re-establish Nebraska's youth's connection to agriculture, increase and engage young farmers in the production and selling of locally grown fruits and vegetables, and aid in the improvement and expansion of Nebraska's farmers' markets. The Nebraska Department of Agriculture (NDA) received $40,650.36 in Fiscal Year 2009 Specialty Crop Block Grant Program – Farm Bill (SCBGP-FB) funds to administer this project.

Project Approach and Goals and Outcomes Achieved

The overall goal of this project was to solely enhance the competitiveness of fruits and vegetables in Nebraska. This was accomplished through FFA classroom and workshop education, engaging students in the growing and selling of local produce, and aiding in the expansion of domestic farmers' markets via FFA youth.

Expected Measurable Outcome #1: Six Nebraska FFA Chapters will participate in this two-year project.

The first goal of this project was to identify Nebraska FFA Chapters who were willing to start their own produce operation. Although no benchmark existed, the target was set to identify six FFA Chapters (three in 2010 and three in 2011). This outcome was achieved. The success of this project was measured by the six schools, identified below, who participated in this project.

2010

In August 2009, NDA worked with the Nebraska FFA Association to conduct a competitive solicitation process to identify three FFA Chapters willing to participate in the first year of this project. The FFA Association sent an e-mail to 136 Nebraska FFA Chapters informing them of this opportunity. Chapters interested in this project were required to respond to this request by writing a one paragraph description as to why their Chapter should be one of the three selected. Conestoga, McCook, David City, and Ravenna were the FFA Chapters who responded. The responses were forwarded to NDA from which Conestoga, David City, and Ravenna were the three initially selected to participate in this project. However, in January 2010, the Ravenna Chapter advisor contacted NDA and asked to have his Chapter's name removed from the selected list. NDA informed the Nebraska FFA Association with this news. Aside from McCook, NDA asked the FFA Association if there were any other Chapters that had expressed interest in this project after the solicitation deadline expired. The Humphrey FFA Chapter had responded with interest, and it was highly recommended by the FFA Association they be selected as the third Chapter to participate in this project. NDA felt as though Humphrey was a better suited to fill this vacancy than McCook. NDA contacted the Humphrey advisor who enthusiastically agreed to accept the offer to participate in this project and filled the slot vacated by Ravenna.

During the selection process, NDA wanted to identify strong, active Chapters that were located in different areas of the state with different topographical landscapes. Although Conestoga, David City, and Humphrey are primarily located in the eastern portion of the state, their soil compositions are different from one another. Below is a list of their respective topographical regions.

> Conestoga consists of hilly land with moderate to steep slopes and rounded ridge crests. The soil is mostly glacial till that has been eroded and mantled by gravel overlain by wind deposited silt (loess).
>
> David City is made up primarily of flat-lying land which lies above a valley. The materials of the plains are sandstone or stream-deposited silt, clay, sand, and loess.
>
> Humphrey consists of flat-lying land along major streams. The materials of the valleys are stream-deposited silt, clay, sand, and gravel.

Following the selection process, NDA discussed the specific plans for this project with each advisor and ordered and compiled specialty crop curriculum documents for distribution to the FFA advisors. Advisors incorporated this information into their classroom lectures, thus accomplishing a portion of the educational component of this project.

2011

NDA revised the application process for 2011. Chapters interested in this project were required to complete an application form that listed applicant details, program eligibility requirements, and a short description as to why their Chapter should be considered for this project. This one-page application form was accompanied by a two-page application instruction sheet that described this project in more detail.

NDA received applications from McCool Junction, Sandy Creek, Schuyler, Mead, and York. The applications were independently reviewed by NDA and the UNL Extension Educator who partnered with NDA on this project. Sandy Creek, Mead, and York were the top three Chapters selected to participate in the second year of this project.

During the selection process, NDA aimed to identify strong, active Chapters that were located in different areas of the state so as to represent different topographical landscapes. Although Sandy Creek, Mead, and York are primarily located from the south central to far eastern parts of the state, their soil compositions are very similar in nature. Their landscapes are primarily made up of flat-lying soil, which lies above a valley. The materials of the plains are sandstone or stream-deposited silt, clay, sand, and loess.

As in 2010, following the selection process, NDA discussed the specific plans for this project with each advisor and ordered and compiled specialty crop curriculum documents for distribution to the FFA advisors. Advisors incorporated this information into their classroom lectures, thus accomplishing a portion of the educational component of this project.

Expected Measurable Outcome #2: The number of young produce farmers in Nebraska, who are participating via their FFA Chapter, will increase by approximately 45 growers in 2010 and 45 in 2011.

The second goal was to increase the number of young produce farmers in Nebraska. Although no concrete benchmark existed, the target was set that the number of young produce growers would increase by 90 (45 in 2010 and 2011) over the course of this two-year project. This outcome was achieved; a total of 105 students participated in this project (59 students in 2010 and 46 in 2011). It was measured by the number of students who participated in this project from each Chapter.

2010

Initially, it was anticipated that 45 students would participate in the first year of this project. This outcome was achieved. Below are the number of participants from each Chapter.

David City	17
Conestoga	28
Humphrey	14

The number of students who participated in the project varied with each Chapter due to the size of school populations and Chapter memberships. David City has the largest student population, followed by Conestoga, and then Humphrey.

Each FFA Chapter produce stand served different populations. David City and Humphrey customers were primarily from their respective towns (and surrounding areas) while Conestoga sold in Plattsmouth, which is a town located approximately 10 miles north of Conestoga High School. The populations of each town are as follows:

David City	2,597
Plattsmouth	6,887
Humphrey	786

In January, NDA ordered 60 books, entitled, *Sell What You Sow*, which were used as the specialty crop curriculum. This was the educational piece from which students received their core classroom education, which was taught by the FFA advisors and NDA's Ag Promotion Coordinator. This book provided practical information to assist growers in successful produce marketing including tips and techniques from master gardeners and experienced marketers. Students were trained on the production practices of fruits and vegetables. They learned basic business practices such as merchandising, customer service, advertising, pricing for profits, and business sense. Through NDA's assistance, they also wrote their own business and marketing plans, each of which were tailored to fit their own produce operation. NDA's initial visit to each Chapter was conducted during the months of January and February. Travel to each Chapter provided instructions regarding the purpose of the project, how it will operate, requirements, and Chapter expectations.

<u>2011</u>

It was also anticipated that 45 students would participate in the second year of this project. This outcome was achieved. Below are the number of participants from each Chapter.

Sandy Creek	25
Mead	6
York	15

As in 2010, the number of students who participated in the project varied with each Chapter due to the size of school populations and Chapter memberships. York had the largest student population, followed by Sandy Creek, and then Mead.

Each FFA Chapter produce stand served different populations. York customers were primarily from York, Sandy Creek sold in Hastings, and Mead sold in Omaha. The populations of each town are as follows:

York	8,081
Hastings	24,064
Omaha	3,100,000

In February, NDA ordered 60 books, entitled, *Sell What You Sow*, which were again used as the specialty crop curriculum. This was the educational piece from which students received their core classroom education, which was taught by the FFA advisors, UNL Extension Educator, and NDA's Ag Promotion Coordinator. This book provided practical information to assist growers in successful produce marketing including tips and techniques from master gardeners and experienced marketers. Students were trained on the production practices of fruits and vegetables. They learned basic business practices such as merchandising, customer service, advertising, pricing for profits, and business sense.

NDA's initial visit to each Chapter was conducted during the months of February and March. The UNL Extension Educator traveled with NDA personnel to be a part of the initial meetings. Travel to each Chapter provided instructions regarding the purpose of the project, how it will operate, requirements, and Chapter expectations.

Expected Measurable Outcome #3: It is anticipated that at least six students will further their education in agriculture, upon completion of this project.

The third goal of this project was to encourage students to further their education in agriculture. Once again, no benchmark existed, but the target was set that at least six students would pursue a degree in agriculture. The outcome of this project was achieved and far exceeded its goal. It was determined that 95 students plan to further their education in agriculture. Student surveys were utilized to measure this goal.

<u>2010</u>
Student surveys were utilized to measure the effectiveness of the educational component of this project. Surveys were written by NDA and presented at the workshops. Questions were directly related to the concepts taught in the *Sell What You Sow* books and the topics addressed at the workshops. Survey responses were evaluated by NDA. A total of 15 questions were asked, all of which were correctly answered by a majority of the students.

NDA visited each of the three schools before the end of the 2010 calendar year to close out the first year of the project. During the visits, NDA's Ag Promotion

Coordinator asked each Chapter how many students planned to further their education in agriculture. It was anticipated that at least three students from the first year of the project would choose the field of agriculture as their career path. However, after the post-projects surveys were completed, received, and reviewed, it was evident that 21 students planned to further their education in agriculture. Below is a breakdown of the number of students from each Chapter who planned to further their education in agriculture.

David City	6
Conestoga	11
Humphrey	4

2011

Student surveys were again utilized to measure the effectiveness of the educational component of this project. The surveys, nearly identical to the ones used in 2010, were written by NDA and presented at the workshops. Questions were directly related to the concepts taught in the *Sell What You Sow* books and the topics addressed at the workshops. Survey responses were evaluated by NDA. A total of 15 questions were asked, all of which were correctly answered by a majority of the students.

NDA visited each of the three schools before the end of the 2011 calendar year to close out the second year of the project. During the visits, NDA's Ag Promotion Coordinator asked each Chapter how many students planned to further their education in agriculture. It was anticipated that at least three students would choose the field of agriculture as their career path. However, after the post-projects surveys were completed, received, and reviewed, it was evident that 32 students planned to further their education in agriculture. Below is a breakdown of the number of students from each Chapter who planned to further their education in agriculture.

Sandy Creek	16
Mead	2
York	14

Expected Measurable Outcome #4: Approximately six educational workshops will be held in Nebraska over a two-year period.

The fourth goal was to conduct educational workshops to train youth on the growing, marketing, and selling practices of locally grown fruits and vegetables. No benchmark previously existed. The target was set for NDA to host six workshops. The success of this goal was measured by the number of students who attended the workshops and their answers provided on the workshop examinations.

2010

Classroom curriculum was reinforced and enhanced by FFA Chapter attendance at workshops developed and organized by NDA's Ag Promotion Coordinator. Educational workshops were held in March and June 2010. Speakers for each workshop included representatives from NDA and a horticulture specialist with the UNL Extension service.

The first was a joint workshop that included FFA students from David City and Humphrey. It was held on March 26th in Columbus, Nebraska, which was a city located between David City and Humphrey. This workshop allowed students to establish relationships with one another, share ideas, and participate in workshop discussions. A total of 22 students, two advisors, an NDA Weights and Measures Inspector, a UNL Extension Educator, and NDA's Ag Promotion Coordinator attended the workshop. The seminar began at 9:00 a.m. and ended at 3:00 p.m. Topics covered at the workshop included crop selection, growing techniques, management practices, stand management, loyalty programs, methods of sale, advertising and promotional campaigns, and marketing and selling practices. The information addressed at the workshop was a built upon the educational curriculum contained within the *Sell What You Sow* book. The workshop training provided students with information from industry experts relating to the growing, marketing, and selling of specialty crops. Student interest in this workshop was remarkable and a joint workshop was noted as a recommendation for the following year.

Conestoga's workshop was broken up into two parts. The first portion was held on April 26th from 1:00 – 4:00 p.m., which covered similar topics related to crop selection, growing techniques, and best management practices. The second was held on June 17th from 10:00 a.m. – 12:00 p.m., which addressed stand management, loyalty programs, methods of sale, and advertising and promotional campaigns. A total of 10 students, a UNL Extension Educator, and NDA's Ag Promotion Coordinator attended both workshop sessions.

Unlike the other two Chapters, Conestoga had a hoop house with raised beds and a drip irrigation system. This facility was used for seed germination and setting plants early in the year. They also had a parcel of land located next to the hoop house, which was used to plant additional produce.

Conestoga FFA Chapter Hoop House

The David City and Humphrey Chapters found several small pieces of land from which to grow their produce. Since one large plot of land was not available, many local farmers set aside small

portions of their land and leased it to the Chapters, free of charge. Although the growing areas were not confined to one location, every student actively participated in the project throughout the year. The Chapters staggered their plantings so as to allow for a consistent supply and large volume of products, on a weekly basis, during the market season.

David City sold their produce at the David City Farmers' Market, which was open Tuesday afternoons from 3:00 – 6:00 p.m. Humphrey set-up a stand at the Humphrey Farmers' Market, which was open Saturday mornings from 8:00 a.m. – 12:00 p.m.

Initial start-up costs can be cost prohibitive. Therefore, upon completion of the trainings, each FFA Chapter was allowed to utilize grant funds to purchase growing tools and booth supplies. Growing supplies purchased included items such as seeds, compost material, fertilizers, insecticides, fungicides, herbicides, shovels, sprinklers, potting mix, cultivators, wheelbarrows, and hoses. Booth supplies consist of items such as certified electronic commercial scales, tables, tents, plastic t-shirt bags, calculators, loyalty cards, and tables. Chapters had the freedom to decide which items to purchase because each Chapter had different needs. However, they were not allowed to exceed their total cost category allotments, unless allowed by NDA.

Each Chapter utilized grant dollars to print newspaper ads, recipe cards, and market signs.

<u>2011</u>
In 2011, two educational workshops were held in March 2011. Speakers for each workshop included representatives from NDA and a horticulture specialist with the UNL Extension service.

The first was a joint workshop that included FFA students from Sandy Creek and York. It was held on March 21st in Aurora, Nebraska, which was a city located between the Sandy Creek and York high schools. This workshop allowed students to establish relationships with one another, share ideas, and participate in workshop discussions. A total of 25 students (11 from Sandy Creek and 14 from York), two advisors, a UNL Extension Educator, and NDA's Ag Promotion Coordinator attended the workshop. The seminar began at 9:00 a.m. and ended at 3:00 p.m. Topics covered at the workshop included crop selection, growing techniques, management practices, stand management, loyalty programs, methods of sale, advertising and promotional campaigns, and marketing and selling practices. The information addressed at the workshop was a built upon the educational curriculum contained within the *Sell What You Sow* book. The workshop training provided students with information from industry experts relating to growing, marketing, and selling specialty crops. Student interest in this workshop was remarkable. As in 2010, a joint workshop was a great success. Joint workshops decreased the number of workshops needed during

this two-year project from six to four. It is important to note that some students who participated in this project were unable to attend the workshop due to previously scheduled school activities.

Mead's workshop was held one week later on March 28th near Ithaca, Nebraska. The seminar times and topics discussed at the previous workshop were addressed here also. A total of 11 students, a UNL Extension Educator, and NDA's Ag Promotion Coordinator attended the workshop. Although 11 students attended this workshop, only 6 actively participated in the project.

Pre- and post-workshop evaluation forms were handed out to workshop attendees to measure its success. Questions pertaining to vegetable production, customer service, business ownership and management, market pricing strategies and practices pertaining to season extension, intensive production, and farmers' market selling practices were asked. Every student said their knowledge increased as a result of the workshop trainings and that it met their expectations.

Sandy Creek and Mead had small green houses and York had a state-of-the art green house. All of these facilities were used for seed germination and plant setting early in the year. The Chapters also found several small pieces of land from which to grow their produce. Since one large plot of land was not available for Mead and York, many local farmers set aside small portions of their land and leased it to the Chapters, free of charge. Although the growing areas were not confined to one location for two of the Chapters, every student actively participated in the project throughout the year. Plantings were staggered so as to allow for a consistent supply and large volume of products, on a weekly basis, during the market season.

Sandy Creek FFA Chapter Garden

Upon completion of the trainings, each FFA Chapter was allowed to utilize grant funds to purchase growing tools and booth supplies. Growing supplies purchased included items such as seeds, compost material, fertilizers, insecticides, fungicides, herbicides, shovels, sprinklers, potting mix, cultivators, wheelbarrows, and hoses. Booth supplies consisted of items such as certified electronic commercial scales, tents, plastic t-shirt bags, and tables. Chapters had the freedom to decide which items to purchase because each Chapter had different needs. However, they were not allowed to exceed their total cost category allotments, unless allowed by NDA.

Expected Measurable Outcome #5: There will be an estimated 10 percent increase in farmers' market sales in 2010 and 2011, as a result of FFA Chapter involvement.

The fifth goal was to increase farmers' market sales as a result of FFA Chapter involvement. No benchmark previously existed. The target was set to increase farmers' market sales by 10 percent in 2010 and 2011. The success of this goal was measured by first establishing a baseline at each market where there was an FFA Chapter presence. This baseline was then compared against each Chapter's revenue. The resulting number was then multiplied by 100 percent. This mathematical equation was used to determine how much of a sales increase there was at each farmers' market. Below is a breakdown of the calculations for 2010 and 2011.

<u>2010</u>
The Conestoga Chapter sold their products at the Plattsmouth Farmers' Market, which was open Saturday mornings from 9:00 a.m. – 1:00 p.m. David City sold their produce at the David City Farmers' Market, which was open Tuesday afternoons from 3:00 – 6:00 p.m. Humphrey set-up a stand at the Humphrey Farmers' Market, which was open Saturday mornings from 8:00 a.m. – 12:00 p.m.

It was anticipated that the farmers' market sales would increase 10 percent in 2010. In order to determine if this outcome measure was achieved, a baseline revenue was established for each market. This baseline was established by multiplying the amount of Chapter revenue by the number of stands at each market. Below is a breakdown of this methodology.

It was assumed that each stand at each market earned the same amount of revenue as the participating FFA Chapter. Below is the amount of income earned by each Chapter at the David City, Plattsmouth, and Humphrey Farmers' Markets, respectively.

David City	$289.34
Conestoga	$1,528.92
Humphrey	$583.44

The numbers listed above are multiplied by the number of stands at each market. Below are the total number of stands that sold produce at each market throughout most of the market season.

David City	5
Conestoga	10
Humphrey	4

To calculate the baseline revenue, Chapter revenue is multiplied by the number of stands to determine the total cumulative revenue for the market. This number is then subtracted from the Chapter's revenue.

David City Farmers' Market	$289.34 (Chapter Income) x 5 (Number of Stands) = $1,446.70 (Total Cumulative Revenue). $1,446.70 - $289.34 = $1,157.36 (Baseline Revenue)
Plattsmouth Farmers' Market	$1,528.92 (Chapter Income) x 10 (Number of Stands) = $15,289.20 (Total Cumulative Revenue). $15,289.20 - $1,528.92 = $13,760.28 (Baseline Revenue)
Humphrey Farmers' Market	$583.44 (Chapter Income) x 4 (Number of Stands) = $2,333.76 (Total Cumulative Revenue). $2,333.76 - $583.44 = $1,750.32 (Baseline Revenue)

The next step is to compare each market's total cumulative revenue against the baseline revenue amounts. This will determine how much of a sales increase there was at each farmers' market as a result of FFA Chapter participation. Below is a breakdown of the calculations.

The David City Farmers' Market's total cumulative revenue ($1,446.70) was 25% higher than their baseline revenue ($1,157.36). Therefore, it is estimated that the David City Farmers' Market experienced a 25% increase in market sales as a direct result of the David City FFA Chapter's participation in the market.

The Plattsmouth Farmers' Market's total cumulative revenue ($15,289.20) was 11% higher than their baseline revenue ($13,760.28). Therefore, it is estimated that the Plattsmouth Farmers' Market experienced an 11% increase in market sales as a direct result of the Conestoga FFA Chapter's participation in the market.

The Humphrey Farmers' Market's total cumulative revenue ($2,333.76) was 33% higher than their baseline revenue ($1,750.32). Therefore, it is estimated that the Humphrey Farmers' Market experienced a 33% increase in market sales as a direct result of the Humphrey FFA Chapter's participation in the market.

As determined above, this outcome measure was achieved at each market. Part of each Chapter's revenue was due largely in part to their promotional efforts via newspaper advertisements, signage, and loyalty programs. These promotional campaigns attracted more consumers to the markets and provided them with a wider selection of produce to choose from. An increase in market traffic helped each stand develop repeat customers and a strong, reliable customer base. It was discovered that consumers were more likely to patronize markets that consisted of more vendors and more produce. It is also important to note that consumers at each market were excited to see young adults involved in the growing and selling of specialty crops. Re-establishing the youth's connection to agriculture, their involvement in the production and selling of locally grown fruits and vegetables, and improving and expanding Nebraska's farmers' markets were major thrusts of this project, all of which were achieved during the first year of the project.

2011

Sandy Creek sold their produce the Hastings Farmers' Market, which was open Saturday mornings from 8:00 a.m. – 12:00 p.m. York sold their produce at the York Farmers' Market, which was open Thursday afternoons from 5:00 – 7:00 p.m. Mead set-up a stand at the Village Pointe Farmers' Market in Omaha. Their hours of operation were Saturdays from 8:00 a.m. – 1:00 p.m.

It was anticipated that the farmers' market sales would increase 10 percent in 2011. In order to determine if this outcome measure was achieved, a baseline revenue was first established. This was determined by multiplying the amount of Chapter revenue by the number of stands at each market. Below is a breakdown of this methodology.

It was assumed that each stand at each market earned the same amount of revenue as the participating FFA Chapter. Below is the amount of income earned by each Chapter at the Hastings, York, and Village Pointe Farmers' Markets, respectively.

Sandy Creek	$732.90
Mead	$329.29
York	$1,552.84

The numbers listed above are multiplied by the number of stands at each market. Below are the estimated number of stands that sold produce at each market through most of the market season.

Hastings	10
Village Pointe	42
York	17

To calculate the baseline revenue, Chapter revenue is multiplied by the number of stands to determine the total cumulative revenue for the market. This number is then subtracted from the Chapter's revenue.

Hastings Farmers' Market	$732.90 (Sandy Creek Chapter Income) x 10 (Number of Stands) = $7,329 (Total Cumulative Revenue). TCR – CI = $6,596.10 (Baseline Revenue)
Village Pointe Farmers' Market	$329.29 (Mead Chapter Income) x 42 (Number of Stands) = $13,830.18 (Total Cumulative Revenue). TCR – CI = $13,500.89 (Baseline Revenue)
York Farmers' Market	$1,552.84 (York Chapter Income) x 17 (Number of Stands) = $26,398.28 (Total Cumulative Revenue). TCR – CI = $24,845.44(Baseline Revenue)

The next step is to compare the baseline revenue amounts for each market against each Chapter's revenue. This will determine how much of a sales increase there was at each farmers' market. Below is a breakdown of the calculations.

The Hastings Farmers' Market's total cumulative revenue ($7,329) was 11.1% higher than their baseline revenue ($6,596.10). Therefore, it is estimated that the Hastings Farmers' Market experienced an 11.1% increase in market sales as a direct result of the Sandy Creek FFA Chapter's participation in the market.

The Village Pointe Farmers' Market's total cumulative revenue ($13,830.18) was 2.4% higher than their baseline revenue ($13,500.89). Therefore, it is estimated that the Village Pointe Farmers' Market experienced a 2.4% increase in market sales as a direct result of the Mead FFA Chapter's participation in the market.

The York Farmers' Market's total cumulative revenue ($26,398.28) was 6.2% higher than their baseline revenue ($24,845.44). Therefore, it is estimated that the York Farmers' Market experienced a 6.2% increase in market sales as a direct result of the York FFA Chapter's participation in the market.

As determined above, this outcome measure was achieved at two of the three farmers' markets listed above. Part of each Chapter's revenue was due largely in part to the large traffic that attended each market. Additionally, more vendors attracted more people. An increase in market traffic helped each stand develop

repeat customers and a strong, reliable customer base. It was discovered that consumers were more likely to patronize markets that consisted of more vendors and more produce. It's important to also note that consumers at each market were excited to see young adults involved in the growing and selling of specialty crops. Re-establishing the youth's connection to agriculture, their involvement in the production and selling of locally grown fruits and vegetables, and improving and expanding Nebraska's farmers' markets were major thrusts of this project, all of which were achieved during this two-year project.

Beneficiaries

The six Nebraska FFA Chapters were one of the beneficiaries of this project. Below is their quantitative data and the economic impact as a result of the project's accomplishments.

Funding Expended During 2010:

David City FFA Chapter	$4,611.17
Conestoga FFA Chapter	$5,263.26
Humphrey FFA Chapter	$5,361.86
Total Funds Expended	$15,236.29

Below is a breakdown of the amount of income earned in 2010, per Chapter, and how it was reinvested.

2010 Program Income

David City FFA Chapter $289.34

All of the program income was used to pay 9 students for working on this project, throughout the 2010 year.

Conestoga FFA Chapter $1,528.92

A total of $885 of the income was be used to pay 28 students for working on this project during the summer. The remaining amount ($643.92) was used to offset the cost of purchasing a tiller. The tiller cost was estimated at $699.99.

Humphrey FFA Chapter $583.44

A total of $583.44 of the income was reinvested into this project before December 31, 2010. The program income was used to pay the students who worked on this project and the 2011 seed costs. A total of $530 was disbursed to 14 students and $53.44 was applied to the 2011 seed cost. The seed cost bill was in the amount of $57.19.

Funding Expended During 2011:

Sandy Creek FFA Chapter	$4,841.54
Mead FFA Chapter	$4,742.51
York FFA Chapter	$6,775.06
Total Funds Expended	$16,359.11

Below is a breakdown of the amount of income earned in 2011, per Chapter, and how it was reinvested.

2011 Program Income

Sandy Creek FFA Chapter $732.90

The program income was primarily used to purchase vegetable seeds and two gift cards. The cards will only be used to purchase additional gardening supplies in 2012.

Mead FFA Chapter $329.29

All of the program income was used to purchase seeds, fertilizer, tomato cages, and a gift card from a seed company. The card will only be used to purchase items additional gardening supplies in 2012.

York FFA Chapter $1,552.84

A total of $1,175 of the income was be used to pay 5 students for working on this project during the summer. The remaining amount ($377.84) was used to purchase additional gardening supplies.

Lessons Learned

This project experienced several challenges; therefore, many lessons were learned along the way.

FFA Chapter expectations must be clearly conveyed and continually reinforced with each participating Chapter. Advisors must be leaders and actively involved in every step of the project. The main eligibility requirements should be included on an application form for interested FFA Chapters to complete. The requirements should describe the expectations and responsibilities of each participating Chapter.

Direction of this project, under the auspices of NDA, was achievable, but difficult. The distance of the Chapter location from Lincoln involved a significant amount of travel time. Therefore, visits were limited, which made oversight of each operation challenging.

NDA made some minor adjustment to this program in 2011. In an effort to streamline the process and increase the relationship between the Chapters and

an experienced crop production specialist, NDA contacted a UNL Extension Educator who worked with the Conestoga FFA Chapter in 2010. This Educator willingly accepted NDA's offer to partner with them on this project throughout the 2011 growing season. Contact with this industry expert provided a resource for Chapters to turn to if they encountered production problems. Seed bed preparation, crop selection, growing techniques, and harvesting practices are key to successful gardens. Recipes to this success were addressed during the workshop and Chapter visits. The Extension Educator's knowledge and instructions in these areas aided in the success of the project. Chapters expressed the need for more lessons on crop production and marketing practices in 2010. It is believed as though increasing the involvement of the Extension Educator's in this project in 2011 helped address this issue and alleviated some of the burden from NDA.

Recording income and expenses was difficult for each Chapter. Instructions of what they were allowed to purchase, how to record expenses, and how revenue could be spent was problematic.

During the first year of the project, it was discovered that Chapters selected in 2011 should be located within a 170 mile radius of Lincoln. Management and oversight of any Chapter located beyond this distance is too difficult and costly for NDA to administer. As a result, NDA altered this project in 2011 from a statewide to a pilot (or regional) project. As in 2010, NDA worked with the Nebraska FFA Association to conduct a competitive solicitation process to identify three FFA Chapters who were willing to participate in this project. Upon NDA's request, the FFA Association sent the application form and instructions to Chapters located within a 170 mile radius of Lincoln only. The three Chapters who participated in 2010 (Conestoga, David City, and Humphrey) were not eligible to apply as a result of their participation the previous year.

During the second year, the advisor from Mead accepted a teaching job at another school. This made it very difficult to close out the project with Mead.

It was discovered that NDA's oversight and management of the participating Chapters are very important. Those located relatively close to Lincoln were easier to manage and oversee. The further they lived from Lincoln, the harder it became to perform oversight.

Regardless of the amount of revenue the Chapters earned, there was genuine enthusiasm about this project that was obvious in 2010 and 2011. Each advisor made a special effort to thank NDA for allowing them to participate in this project. The entrepreneurial lessons the students gained from this experience was priceless.

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Additional Information

None.

Project Title

The Farmers' Alternate Crop: Winter Production of Greenhouse Strawberries

Project Summary

Nebraska is known for its agricultural field crop production. This is due to abundant sunshine, warm temperatures, and plentiful moisture. However, some of the sunniest days of the year are during the winter months. This underutilized solar energy can be used for controlled environment agriculture (CEA). With uncertain transportation costs, food safety concerns, human health and obesity issues, and the need to improve local economies, increasing local production of fresh fruits and vegetables is a logical set for Nebraska. Growing food under a greenhouse allows Nebraska farmers an additional source of income. Greenhouses utilize as much as 60 percent of their budget towards heating indicating that sustainable but cost-reducing methods will translate into increased profits. Therefore, this project created a cost-effective model or prototype for growing horticultural crops during the winter months in Nebraska. Crop trials of 12 different cultivars of strawberries were tested, including cultivars specifically developed for the short day photoperiods that occurring during winter. The fruit was tested for their health-promoting properties while tracking construction, production and greenhouse energy costs and marketing to increase profitability. The overall goal of this project was to enhance Nebraska's economy by growing high value horticultural crops during the winter months.

Project Approach and Goals and Outcomes Achieved

December. Upon receipt of grant monies, Professor Stacy Adams constructed benches to support a CapMat system, installed new heat tubes, capillary mats, reflective white plastic covering for the bench, a water meter and irrigation system, and a gas meter to monitor fuel usage. Using NE 1035 multistate funds, Dr. Meyer installed instrumentation and a monitoring computer to record greenhouse air, crop, and pot temperatures, humidity, pot moisture, and photosynthetically-active-radiation (PAR) at the north, middle, and south zone locations of the greenhouse. Outside temperatures, humidity, wind speed, and total available radiation were also recorded. Ventilation fan activity and the natural gas furnace operation were also logged. The instrumentation along with a web cam was available over the Internet.

January. A strawberry experiment design was created (6 replications containing 4 plants in each replication; 13 cultivars), holes in plastic for pots were cut with an innovate tool, strawberry plants were repotted and placed on February 3rd in the proper bench sections. From this point forward, Ms Elizabeth Conley, research technologist, checked plants daily and collected observational growth and development data.

February – March. Special bees for pollination were introduced. On March 3, the first strawberries were harvested, counted, and individually weighed. Sample berries from each replication for each cultivar were harvested and frozen at 80^{o}C for nutraceutical analysis. Using, the RHS Color Chart, strawberries were deemed ripe when their color matched those purchased from the grocery store.

April. Daily harvest continued until April 14. At this time, the temperatures were getting too warm in the greenhouse, so the experiment was concluded.

May – September. Approximately 1,800 berries from 312 plants were produced using only 36 gallons of water. For the nutraceutical analyses, data has yet to be statistically analyzed. However, based on gross averages, it appears that there was little difference between total phenol concentrations among the 13 cultivars. However, on average, total flavonoid concentration (mg catechin equiv. per g sample) ranged from 0.2781 in AC Wendy berries to 0.6235 mg per g in DarSelect berries. Total antioxidant concentrations, on average, ranged from 32.7513 in AC Wendy berries to 77.6889 mole Trolox in Strawberry Festival berries. With such wide ranges such as these, it is anticipated that we will be able to statistically prove that certain cultivars produce the higher concentrations than others. It was also noted that over this seven-week harvest period 5 cultivars (Albion, Evie-2, Honeoye, Seascape, and Strawberry Festival) each produced over 150 berries from 24 plants. However, this does not necessarily correspond to total weight produced or mean berry weight per cultivar as AC Wendy produced fewer, but consistently heavier berries than Seascape, for example. Also, peaks in berry production among cultivars varied. For example, AC Wendy berry production peaked at week six while Albion peaked week four of production. DarSelect did not start producing berries until week four.

Extension outcomes – A strawberry poster with some of the above results was presented at the International American Society for Horticultural Sciences meeting in Palm Dessert, California. The research on the colored polyethylene reflectivity studies was presented at the International American Society of Agronomic and Biological Engineers meeting in Pittsburgh, Pennsylvania. It is estimated 500 to 600 people heard one of those presentations. The web site is under development, but can be viewed at http://agronomy.unl.edu/cea. Results were also presented at the annual meeting of NE1035 in Madison, Wisconsin (no travel costs were paid from this grant).

Comparison of Actual Accomplishments with Goals

GOAL 1. Determine if a particular color of poly mulch will promote heat retention and/or increased light reflection to aid plant growth and reduce heating costs (duration: 3 months)

Step 1. Set-up reflective colored polyethylene mulch trials (red, olive green, white and black). Dr. George Meyer, a university UCARE student, and Dr. Paparozzi

will measure quantum light quality and quantity, temperature, relative humidity continuously for each color poly. This information will be compared to outside temperatures and greenhouse 66, which will receive a new poly glazing.

RESULTS. This goal is complete. The white poly mulch improved reflection. (A short report has been published and accessible via the web site.) The next step was to use it to cover the capillary mat for this year's short spring experiment and take measurements.

GOAL 2. Minimize and contain all water and fertilizer (no run-off)

Step 2. Replace the older poly on Greenhouse 68, to further improve quantum availability and set up benches and sustainable fertigation/capillary mat system. (Duration: 1-2 months) Asst. Professor of Practice Stacy Adams, M. S; and M. Elizabeth Conley, M. S. Research Technologist will verify the increased light levels and test the system.

RESULTS. This has been accomplished and the system is running smoothly. The measurements taken this coming growing season (GOAL 1) will tell us how much the light has improved. The reflectance measurements indicate that, compared to the gravel, the 6-mil poly covering will increase between 50 and 80% over the gravel (See Graph 1 found at end of this report).

GOAL 3. Scientifically validate the choice of colored poly to cover the capillary mats.

Step 3. Integrate the quantum energy balance (Step 1) into the current NCESR real-time greenhouse instrumented adaptive monitor program (a Labview 8.6 program that monitors the greenhouse environment, energy use, crop temperature, and moisture balance every 24 hours per day) (Duration:1- 3 months) Dr. George Meyer and one university UCARE student.

RESULTS. These measurements are ongoing and Dr. Meyer and Dr. Paparozzi are in the process of writing a scientific paper specifically on the colored mulch reflectance study research. This document is in its final review for the *Engineering in Agriculture* journal. Just the review process before its final publication usually takes about 4 – 6 months.

GOAL 4. Determine which cultivars produced the most berries, as well as how long each cultivar will produce berries

Step 4. Conduct the strawberry trials. (Duration: 6 months) Dr. Ellen Paparozzi, Dr. Paul Read, and M. E. Conley, M.S. Research Technologist. UNL's experimental design is a randomized complete block design with two greenhouses and two benches per greenhouse. Number of berries and weight of berries will be recorded on a daily and weekly basis once fruiting has begun.

RESULTS. There are two experiments necessary for final selection of cultivars. The preliminary experiment is completed and the results are discussed above. During 2010-2011, which was a full growing season, berry production trends were carefully recorded. The cultivars that gave the highest yield were Chandler, Albion, Seascape, Cavendish, and Evie-2. The cultivars that produced the most weight (mass) were the same as those that produced the highest number of berries. However, not all of the cultivars flowered and fruited during the target period of November and December.

The full growing season experiment is concluded. Data was collected and reviewed in order to design the final experiment, which is currently underway. The 6 cultivars plus 2 of those cultivars at a higher grade (A+) have been potted and all are currently flowering and fruiting.

GOAL 5. Compare the nutraceutical properties among the various cultivars and grocery store strawberries to determine which will produce the greatest health benefit.

Step 5. Determine sugar and nutraceutical properties of winter-grown strawberries from our greenhouse trials and the grocery store. (Duration: 4 months) Dr. Vicki Schlegel and her research team will process strawberries in her Food Science Lab.

RESULTS. Preliminary results are reported above and data are in the process of being analyzed. The moisture content of the berries was a surprising 90%.

UNL plans on sampling again this year, but not all six replications and probably not all chemical compounds due to a cut in budget for the second year of our funding. The data for 2011 has not yet been statistically analyzed.

GOAL 6. Identify the initial capital investment and baseline operational costs for winter strawberry production.

Step 6. Amass and calculate costs of construction and equipment for sustainable poly house. (Duration: 5 months) Asst. Professor of Practice Dave Lambe, M.B.A.; Asst. Professor of Practice Stacy Adams, M. S.; and Dr. Ellen Paparozzi

RESULTS – Initial capital construction costs and operational costs have been compiled to determine preliminary start up and continuing costs of growing wintertime strawberries. A *NebGuide* type of publication is planned for December 2011. Professor Lambe and Dr. Paparozzi are planning to complete this goal next month (December 2011). The information will eventually be available through UNL.

The full growing season experiment is concluded. Data was collected and reviewed in order to design the final experiment, which is currently underway. The 6 cultivars plus 2 of those cultivars at a higher grade (A+) have been potted and all are currently flowering and fruiting.

A website was completed and made available to member of organizations such as the Nebraska Sustainable Ag Growers and Farmers Markets. A video of the project was created and posted on the website. The website address is http://agronomy.unl.edu/cea. A total of 158 hits were made to this website as of October 31, 2011.

Other outreach presentations such as an appearance on *Backyard Farmer* are planned for Spring 2012.

Other outreach presentations such as an appearance on *Backyard Farmer* are planned for Spring 2012.

A *NebGuide* discussing the construction of low cost greenhouse benches with capillary mat automatic watering system is currently being drafted.

The second greenhouse with the proper benching system, fertigation, heating and fan system will be constructed for use starting January 2012.

A strawberry poster was sent to the 2011 Great Plains Growers Conference (formerly the Annual Missouri Small Fruit and Vegetable Growers Conference). There were 466 attendees plus 92 exhibitors and 78 speakers/organizers from Iowa, Indiana, Kansas, Missouri, Nebraska, Ohio, Oklahoma, Texas, South Dakota and Arizona.

An oral presentation by Dr. Paparozzi was given at the National American Society for Horticultural Science meetings this past September. A total of 900 people attended this conference. Dr. Paparozzi's presentation was selected to be podcasted and will soon be posted on the website http://agronomy.unl.edu/cea.

Beneficiaries

This research project will benefit farmers and current crop producers. It will impact agronomic famers and current vegetable and fruit growers (including organic farmers) that sell through direct market outlets, such as farmers' markets and roadside stands. A special target audience include women as this system does not require heavy equipment or labor, depending upon the size of the operation. The actual growing of the crop requires minimal maintenance and current farmers would not necessarily be required to give up off-season jobs that provide off farm profits and benefits. This project found an innovative, cost-effective, alternative method to maintain consistent berry production. It is

believed that this project is appealing to commercial partners and entrepreneurs who seek alternative avenues with which to maintain plant health and berry production.

Lessons Learned

There was a problem ordering and paying for the strawberry plants. The grant started in October 2009, but money did not come until December. Plants are usually ordered in February and March. It was fortunate that a nursery and two of UNL's colleagues at other universities were able to supply the plants. They allowed UNL to delay payment until the money became available. This provided UNL with the opportunity to do a preliminary cultivar selection experiment from January through April 2010.

Last year, UNL projected having a second greenhouse fully operational by September 2011. However, due to loss of two undergraduate assistants (one due to illness and the second due to excessive course load) and loss of the supplemental funding associated with those students, the project is several months behind schedule. UNL has located $975 of additional funds and they are working with their facilities manager to have other staff assist them with finishing this part of the project.

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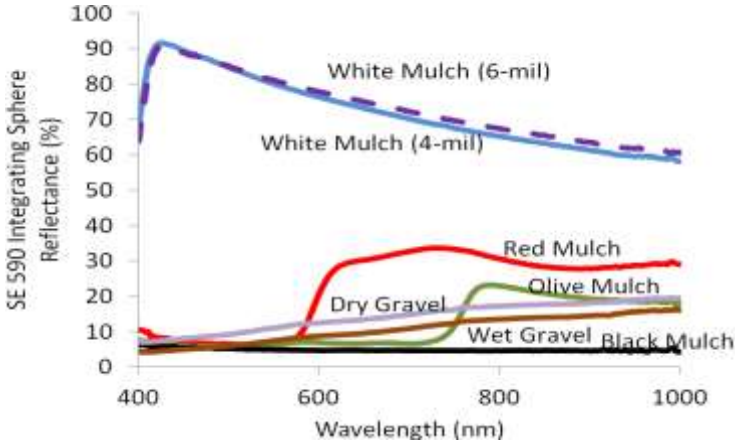
Additional Information



Graph 1. Integrating sphere analysis of reflectance of plastic mulch samples, and wet and dry gravel.

Project Title

Increasing Consumption of Dry Edible Beans in Nebraska Child Nutrition Programs

Project Summary

The USDA has established the HealthierUS School Challenge Program, which requires school nutrition programs to serve dry edible beans once a week in the amount of ¼ cup per serving, per student. Inclusion of beans in the diet has been shown to improve overall nutritional status. Currently, the Nebraska Child Nutrition Program has a limited amount of recipes to utilize dry edible beans, either canned or dry-packaged beans, which are available in USDA Commodity Food Programs for Nebraska schools. This project proposed the utilization of existing dry bean recipes including Cowboy Pizza, Beanie Vegetable Soup, and Enchilada Casserole. The current recipes were modified to use Great Northern Beans while retaining the appeal of the original recipe in a partnership with the University of Nebraska –Lincoln (UNL), Department of Nutrition and Health Sciences Culinology® program. The Nebraska Dry Bean Commission's partnerships shared a common goal of increasing the awareness of healthy bean recipes that can be utilized by the Nebraska Child Nutrition Programs and assist Nebraska schools in meeting the HealthierUS School Challenge Program's usage of dry edible beans. The Nebraska Dry Bean Commission had one or all recipes demonstrated at the 2010 Nebraska School Nutrition Associations annual meeting. Through continued discussions, the Commission proposed taking the Cowboy Pizza recipe to a commercial vender for commercial preparation and to make it available to the Nebraska Child Nutrition Program. This project supported the Nebraska Dry Bean Commission's goal of increasing edible dry bean consumption on a state and national level

The motivation for the project was to enhance consumption and add value to Nebraska dry edible beans by developing foodservice quantity recipes. The award winning recipes were a bean based soup, a black bean and pork pizza, and enchiladas. Based on the knowledge that the recipes were accepted as family favorites, it is feasible that the recipes will acceptable in volume feeding operations, such as school foodservice.

Project Approach

To support the goal of increasing fiber in food items consumed in the Nebraska Child Nutrition's school lunch program, three consumer recipes (Beanie Vegetable Soup, Cowboy Pizza, and Enchilada Casserole), winners of the 2008 and 2009 Nebraska New Pork and Beans contest were developed into quantity recipes (40 or 50 servings). The initial step of the project was to determine the sensory profiles of the consumer recipes in order to match the characteristics of the consumer and the final quantity recipes with each consumer recipe being prepared three times. This step

resulted in the development of a sensory evaluation sheet. As retail and wholesale food products differ, wholesale food items were purchased and used in production of the quality recipes.

The three recipes were modified from consumer to volume recipe quantities of 50 to 100 portions. The consumer recipes were initially prepared as submitted for the contest to determine yields and to determine the baseline sensory quality characteristics: overall appearance, color, texture, beany flavor, flavor intensity, residual flavor, salt and fresh appearance.

The Beanie Vegetable Soup was prepared five times, each time comparing the consumer recipe with the volume recipe. An adjustment was to change from small diced pork loin to coarse ground pork butt. This reduced the cost of the pork and the amount of manual labor required to dice the pork. Yields and sensory analysis was consistent during the fourth and fifth preparation to confirm the sensory profile matched the original consumer recipe. Through changing the tomato type, Beanie Vegetable Soup became two recipes, Pork Chili (crushed tomatoes) and Southwestern Bean, and Pork Soup (diced tomatoes).

Pizza was prepared a total of nine times. Initially, the crust presented problems. Finally, a pourable pizza crust recipe was tried and the results were excellent. With resolution of the crust issue, the volume recipe was modified to incorporate a combination of Great Northern and Black Beans. With the bean ratio established, the final step was to mimic the sauce, originally a retail spaghetti sauce. After the sauce profile was verified, three additional trials were completed to verify that the flavor profiles of the consumer and quantity recipes were consistent. Members of the Dry Edible Bean Commission sampled both the soup and pizza on a March 3rd visit to Lincoln. The group provided feedback while indicating that the soup and pizza were items they would eat.

The Enchilada Casserole was prepared six times. The consumer recipe was determined to be bland in color and flavor and too moist. In addition to reducing the liquid, additional corn tortillas and whole kernel corn was added. The ground pork was changed to ground beef to improve the color. Additional jalapeno peppers were added to enhance the flavor. The casserole now is firm enough to be portioned into squares for ease of service.

Ingredient weight and measure proportions were monitored to ensure that ingredient ratios were consistent between the consumer and the quantity recipes. The cost/serving for each recipe, based on the wholesale purchase price, follows: Pork Chili, $0.74; Southwestern Bean and Pork Soup, $0.84; Cowboy Pizza, $0.94; Beef Enchilada Casserole, $0.84. Cost reductions of approximately $0.10/serving could be achieved if dried beans, instead of canned beans, are used in the recipes. Cost reductions could also occur with the use of USDA commodities in the product.

Nutrition Facts were completed for the four recipes. Based on a 2000 calorie diet, nutrient values of interest for the Child Nutrition Program for the recipes are as

follows: Pork Chili: Total Fat, 9%, Sodium, 22%, Dietary Fiber, 24%; Southwestern Bean and Pork Soup, Total Fat, 9%, Sodium, 23%, Dietary Fiber, 20%; Cowboy Pizza, Total Fat, 20%, Sodium, 20%, Dietary Fiber, 12%; Beef Enchilada Casserole, Total Fat, 20%, Sodium, 25%, Dietary Fiber, 16%.

When a group of 20 University Dining Students evaluated the items, they indicated that both the pizza and the soup are items they would select. The students recommended changing the name of the soup to Southwestern Bean soup, because of the flavor. When the bean soup was served to high school students attending State FFA Convention, 90 percent indicated that they would eat the soup. Eight percent of these students indicated that the soup could be too spicy for grades K-4. NTENT participants evaluated the Southwestern Bean Soup, the Cowboy Pizza and Enchilada Casserole. All the participants agreed that the students in their Child Nutrition Programs would accept the soup and the pizza. Most NTENT participants (78 percent) felt that the Enchilada Casserole would not be acceptable — the participants described the casserole as being too soft and lacking color. They commented that, in general, students do not prefer casseroles.

University Dining Service evaluated the ease of production and facilitated student evaluation of the items.

Goals and Outcomes Achieved

Goal: University of Nebraska-Lincoln Culinology® program will modify current consumer recipes to utilize Great Northern beans while retaining their appeal, upscale recipes for institutional use, including nutritional information so recipes can be presented to Nebraska Child Nutrition Program. **Outcome:** Three consumer recipes were expanded to volume recipes of 50 servings.

Goal: Culinology® students will perform taste tests at University residence halls taste test data will be collected. **Outcome:** University Dining Service Students have indicated that both the pizza and the soup are items they would select. The students recommended changing the name of the Beany Vegetable Soup to Southwestern Bean soup.

Goal: Coordinate with NTENT (Nebraska Training and Education for Nutrition teams) program dry bean recipes will be served as a menu item to 45 school nutrition professionals during summer of 2010 program. **Outcome:** The USDA has established the Healthier US School Challenge Program, which requires school child nutrition programs to serve dry edible beans once a week in the amount of ¼ cup per serving. The Nebraska Department of Education is a strong proponent of the Challenge. In June 2011, the recipes were evaluated and shared with school food service managers attending the 2011 Nebraska Training and Education for Nutrition Teams (NTENT) workshop. Participants evaluated the soup and pizza and agreed that these were items that K-12 students would select in their Child Nutrition Programs.

Goal: Coordinate with Dr. Bev Benes, Director of Nebraska Nutrition Services, demonstrate recipes, ease in preparation and educate participants on how best to utilize dry beans that are available in USDA Commodity Food Programs and educational information on how to get students to be a "Bean Counter" during the 2010 NSNA Convention. **Outcome:** Not completed. Unable to secure program time from the 2010 NSNA Convention Program Planning Committee. Request for a session for 2012 has been submitted.

Goal: Work with the Alliance for Healthier Generation in Nebraska to identify additional possibilities for distribution of healthy bean recipes within their program. **Outcome:** Administrative personnel changes in the Nebraska Department of Education Child Nutrition Program and pending USDA Meal Pattern Guidelines have slowed distribution of the recipes. The Department continues to express an interest in recipe distribution and has committed to using the Recipes in the 2012 NTENT program sponsored in part by the Department of Nutrition and Health Sciences, University of Nebraska Lincoln.

Goal: Will identify additional agencies and opportunities to assist in educating Nebraska's youth about healthy eating habits and the benefits of including dry edible beans in a healthy diet. **Outcome:** The Nebraska Dry Bean Commission, The Nebraska Restaurant Association and The Department of Nutrition and Health Sciences are co-sponsoring a session for Nebraska Family and Consumer Science Teachers who teach ProStart, a secondary school program in Culinary Arts and Foodservice Management. Teachers will prepare and enjoy the three standardized recipes from this project as well as begin to develop unique recipes using dry edible beans. The 2012 Nebraska ProStart Culinary Competition will require that dry edible beans be a component of their three course meal.

Goal: Continue discussions with interested company for commercial manufacturing of Cowboy Pizza. **Outcome:** While discussions have occurred with a local pizza chain, this goal has not been accomplished.

Beneficiaries

The beneficiaries of the project include the Nebraska Department of Education Nutrition Services Division, Nebraska School Foodservice Managers, Nebraska children, and the students who worked on the project.

Nebraska School Foodservice Managers have new recipes to include in their menu planning. Inclusion of the three recipes as menu choices will facilitate budget control. Nebraska children, who participate in the School Lunch Program, will have additional menu choices that are nutritious and flavorful. Finally, the students working on the project gained an appreciation for research planning and process.

Lessons Learned

Recipe development is much more than increasing the amounts in the original recipe. Differences exist in the quality levels between wholesale and consumer ingredients, with color and texture changes occurring with adjustments in ingredient amounts and equipment used. Developing the sensory scale is a lengthy process as few individuals taste the same way. Development of the sensory scale was critical to retaining the integrity of the flavor, texture and visual appearance of the original recipes, when Great Northern Beans were added to the recipe.

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Additional Information

None.

Project Title

Extending Specialty Crop Growing in Nebraska

Project Summary

Community CROPS was able to utilize grant funding to improve the capacity of socially-disadvantaged and beginning farmers through workshops, farm tours, farmer-to-farmer mentoring and networking. Interest in locally-grown produce has risen rapidly in recent years, but there are not enough producers to meet demand. Growing specialty crops requires a diverse skill-set, including business planning, budgeting, marketing, and scaling-up effectively. Beginning farmers, especially socially-disadvantaged and immigrant farmers, lack the skills necessary to begin and sustain successful specialty crop production. In 2008, Community CROPS began a project through the SCBGP-FB to increase ethnic specialty crop production. This project increased the diversity of vegetables that farmers produce, and it also expanded the markets in Lincoln. This project benefited from market expansions and assisted in training more growers to fill those markets.

Beginning farmer workshops educated people interested in producing specialty crops, including vegetables, fruit, herbs, and flowers, in a sustainable manner. They were day-long workshops that enabled people within a two-hour driving radius of Lincoln to attend for the day and return home in the evening. Workshops covered topics including business planning, marketing, Integrated Pest Management, and more. Farm tours allowed beginning and socially disadvantaged farmers to see successful operations and network with one another. Additionally, Community CROPS facilitated farmer-to farmer mentoring and work exchange for participants to work more closely with an established farmer in their area.

Project Approach

This project consisted of three components: workshops, farm tours, and mentoring. Below are the activities performed.

Grant Objective: Develop and implement five to six day-long workshops for sustainable beginning producers of specialty crops.

In 2010, this project funded winter and summer workshops.

Six workshops were organized.

28 People attended the Explore Farming class.
22 People completed surveys.
15 People rated the workshop as a 4 or 5 out of 5.

9 Participants said they have decided to start an agricultural business, ten were undecided and three decided not to start an agricultural business. Participants indicated need for further assistance in all areas, but especially planning and business skills, accessing land, marketing, and product pricing.

Four day-long workshops were held in the spring as part of an eight-workshop series. Topics covered included:

1. Seed production;
2. Organic management of soil, pests, diseases, and weeds;
3. Harvest and packing techniques; and
4. Use and maintenance of tools and equipment.

In 2011, Community CROPS received a grant from the Farmer's Market Promotion Program, which funded the winter workshops, so the focus of this project shifted to the spring trainings and extending them into a summer workshop series. Five workshops were held, covering a wide variety of topics. Forty people attended one or more workshops, and the average attendance was twelve. Three classes were held at Sunset Community Farm: Small Engine Repair, Pest Management, and Season Extension. One class (Pruning and Trellising) was held at Common Good Farm, and another (Harvest and Post-Harvest Handling) was held at Shadowbrook Farm.

Workshop Name	*Attendance*	*Surveys Returned*	*Average Rating**
Small Engine Repair	7	6	4.72
Trellising and Pruning	13	1	4.64
Post-Harvest Handling	4	3	4.84
Pest Management	19	16	4.75
Season Extension	20	0**	--

*out of 5
**No surveys were prepared for this class

In addition to the summer workshops, two Explore Farming workshops were held for prospective farmers. Twelve people attended these workshops, which provided an overview of specialty crop production, resource lists, and a farmer panel. Twelve surveys were returned, and the average rating (with 5 as the best) was 4.125.

Grant Objective: Hold three to four farm tours on the days of the workshops at successful farms that produce specialty crops.

Below are the results of 2010:

1. Campbell's Nursery
2. Sunset Community Farm
3. Common Good Farm
4. Harvest Home Farm
5. ShadowBrook Farm
6. Plains Power of Seward

29	People attended one or more of these workshops. Presentations were made by a variety of people, including several local vegetable farmers, the produce manager of a local grocery store and a farm equipment dealer.
28 of 33	Completed surveys from these workshops rated them as “good” or “great.”
12	People attended one summer field workshop on Post-Harvest Handling. This was presented by Kevin Loth at his farm, ShadowBrook Farm.
9	Surveys were completed, and all 9 rated the workshop as good or great.

Factoring in repeat attendees, 52 people received training on topics related to starting a sustainable, direct-market vegetable operation in 2010. Twelve people started or maintained a small farm business growing specialty crops. Those who attended workshops but did not start a small farm business had a variety of reasons. Some reasons included lack of access to land, change in job or family situations, home gardeners wanting to improve their gardening skills but not start a business, or conventional or commodity crop producers who were starting to explore organic methods or specialty crops for added income.

The target outcome was for 50 people to gain skills or knowledge over the two-year project. This goal was achieved. Another target outcome was for 30 farmers to maintain their farm through 2011. A total of 12 participants operated a farm during 2010.

In 2011, tours were held at three farms: Common Good Farm, Shadowbrook Farm, and Sunset Community Farm. Participants were exposed to a wide variety of crops and production techniques at these farms. CROPS also hosted a half-day tour at Sunset Community Farm for potential refugee farmers, which nine people attended.

The topics addressed during the trainings were limited to specialty crop production only, even though many of the farms mentioned above sell more than just specialty crops. For example, at Common Good Farm, participants attended a session entitled, “Pruning, Trellising, Pinching and Mounding for Vegetable Crops.” At Shadowbrook Farm, a class entitled “Harvest and Post-Harvest Handling” addressed the handling of produce from the field to the market. The vast majority of Community CROPS trainings are limited to specialty crop

production only and all of the summer workshops paid for by SCBGP funds were limited in this way.

Grant Objective: Facilitate mentoring and work exchange relationships between beginning and established farmers to foster continued learning for both parties.

The goal was to develop a mentoring program for beginners to learn from established farmers, and to have 10 participants in 2010. Planning for this program began in the spring, but then learned that another local organization, which focuses on sustainable agriculture, was also planning to start a mentoring program. Community CROPS did not feel it was appropriate to start two separate programs, so they met with them to explore how the two organizations might be able to create one together. Several meetings later, it became clear that they were not prepared to start the program this year, but would like to establish one in the future.

By this time, the season was well underway, and it was unrealistic to establish a brand new program or expect established farmers to find the time to provide input on how to structure it. Thus, informal mentoring occurred, but a structured program was not established. Informal mentoring took place on topics including designing a washing and packing shed, planning plantings for cut flowers and setting product prices. Significant one-on-one support was provided to growers at Sunset Farm by CROPS staff as well.

CROPS believes that mentoring is still an important learning opportunity for beginning farmers, but if another local organization intends to also start a program at some point, they want to be careful not to place too much burden on existing farmers. There are a limited number of potential mentors in the area, as specialty crops are still not grown by a significant number of farms. They will continue their conversations with the other organization, but will also scale back their goal for a number of participants and number of hours they spend together. A less-formal program, where mentees meet their mentor and are encouraged to call or visit with questions, but no expectations are in place for number of contact hours, will probably be more realistic. This also means that staff time devoted to one-on-one support of beginning farmers will remain very important.

The successes of 2010 are as follows:

- One new CSA was started by Fox Run Farm in Brainard! They had a great 2010 season and were planning to expand in 2011.
- Two new families began growing vegetables, herbs and cut flowers at Sunset Community Farm. They sold $3,400 of product through the CROPS CSA, the Old Cheney Road Farmers' Market and to local grocery stores such as Open Harvest and Red Clover.
- One family graduated from Sunset Community Farm this fall. They have secured a site for 2011 where they will rent approximately ¾ acre and will

have some storage space. They plan to grow a variety of vegetables and sell at the Old Cheney Road Farmers' Market and start their own CSA. At the market in the fall of 2010, they invited interested people to sign up for more information about their CSA. They had a list of 15 people.

- A father-son operation grew several varieties of hot peppers for a local restaurant to turn into hot sauce.
- The CROPS CSA grew from 50 families in 2009 to 115. This translated into $13,000 of income for the families growing produce at Sunset Farm.

In summary, brand-new producers of specialty crops are emerging out of the workshops, and advanced producers are increasing sales and improving product quality and availability in year two and beyond.

The focus of this project changed from a formal to an informal mentoring program. Two factors contributed to this decision:

1. Few specialty farms exist in the area to provide mentors, and

2. Another organization planned to organize a mentoring program and plans to collaborate fell through.

CROPS has continued their informal mentoring of participants at Sunset Community Farm, and they set up a business mentoring partnership with student volunteers from the University of Nebraska beginning in winter 2011.

Goals and Outcomes Achieved

This project outlined three outcomes:

Skills: Fifty beginning farmers who attend workshops will gain improved skills and knowledge in sustainable farming.

Community CROPS met this goal by providing training to 52 beginning farmers in the first year of the project and increased the goal for the project from 50 to 75 farmers. In 2011, an additional 52 people attended training, bringing the total trained to 104.

Farming: Thirty beginning farmers will maintain their farm businesses through 2011.

Since the beginning of the project, CROPS has helped twenty beginning farmers maintain their farm businesses. All of these farmers received support through workshops, and eight also received training and one-on-one mentoring at Sunset Community Farm. CROPS is excited about the success these farmers have experienced, but are disappointed that they did not reach their goal. Two factors played a role in this outcome.

First, many participants in their workshops chose to go through more training before starting their own farm businesses. When they were planning the project, they anticipated that all of their workshop attendees would either have started or would be immediately starting specialty crop production. Instead, many attendees learned through the course of several classes that they were not ready to begin their own business and chose instead to work for an existing farm or seek additional training elsewhere.
Second, CROPS focused their services on the eight participants who farmed alongside us at Sunset Community Farm. This kept them from maintaining contact with the other 96 farmers who went through the workshops. It could be that more of our class participants went on to start farm businesses without the knowledge, or perhaps others would have begun production if they had received more support. In either case, more intentional follow through with these 96 may have resulted in more specialty crop production and a higher success rate in this outcome.

Mentoring: Ten beginning farmers will participate and gain experience in the mentoring program in 2010, and ten additional beginning farmers will receive mentoring in 2011.

As stated previously, CROPS did not meet their objective to start a mentoring program. They were able to informally mentor the eight participants who farmed at Sunset Community Farm, but a formal mentoring program was not established.

Beneficiaries

The beneficiaries of this project are the farmers who went through the workshop series and received one-on-one mentoring from CROPS staff. Few farmers exemplify this better than Memphis, a grower from Togo, who is in his third year at Sunset Community Farm. Memphis has learned to grow a wide variety of crops efficiently, and his sales record shows it. In his first year, Memphis sold $1,600 of produce, and this year, he has sold over $9,300. CROPS staff played a large role in his success, connecting him to markets like Open Harvest, the local coop grocery store, the online Nebraska Food Coop, and buying large quantities of his produce for the CROPS CSA. Memphis's success is a testament to his hard work and dedication, and we believe it also shows the quality of the training he received.

Other beneficiaries are the vegetable consumers in the Lincoln area. The Community CROPS CSA, which grows and purchases all its produce in the Lincoln area, provided over 17,000 pounds of fresh vegetables, fruits and herbs to Lincoln residents. Many of the vegetables also find their way to at-risk youth in the community through a recent partnership with the foster care agency, CEDARS.

Finally, many Lincoln residents buy produce from CROPS and the Sunset Community Farmers at the Old Cheney Road Farmers Market. In September of 2011, Community CROPS hosted over 140 people at a free outreach event at Sunset Community Farm. Attendees talked with the farmers, learned about specialty crop production (including vegetables, berries, medicinal herbs, and honey), and enjoyed children's activities.

Lessons Learned

Community CROPS learned several lessons through this project. First, they noticed that there is a high demand for quality instructions about specialty crop production. They went far beyond their estimate for workshop attendees. They believe that, with better organization and marketing, their workshop attendance will increase. The formal, comprehensive winter workshop series has only been in existence for two years and is rapidly growing as more people learn about it.

Second, CROPS realized the difficulty of following through with workshop attendees in order to encourage specialty crop production. Their office manager worked hard to keep in contact with producers, but it was difficult to get people to respond. The task of starting a small farm is daunting and believe that it is important to provide support to beginning farmers. Their farm program manager plans to restore contact with the attendees this winter in order to better understand how to meet their needs and to invite them to continue to participate in CROPS workshops and other training events in Nebraska. In addition, many people chose to not start farming immediately when they realized through the training that they were not prepared to start a business. They look forward to continuing to offer training and support to these individuals to help them gain the resources and education they need to make their farm ventures successful.

Third, they recognize the need for a more intentional approach to mentoring. At the CROPS farm, they are going to implement a more structured mentoring atmosphere by assigning each staff member with a specific farmer. They are also planning to invite previous graduates of our program to attend any workshops they wish for free. This will allow them to continue to refine their skills, and it will also open the door for peer-to-peer mentoring as they offer practical advice to other beginning farmers.

Finally, CROPS reaffirms the importance of one-on-one mentoring, as well as land-based training. Their current farm site is limited to six or seven participants per year, which prevents them from reaching out to more farmers. Fortunately, in 2013, CROPS plans to move to Prairie Pines, a site owned by the University of Lincoln (UNL) Foundation and managed by the University. This farm has over 15 acres of hay that CROPS plans to convert to specialty crop production, beginning with four acres in 2013. They anticipate many opportunities for collaboration with

UNL, the USDA, educators, and researchers as they develop this farm into a training farm for beginning Nebraska specialty crop producers.

In conclusion, the SCBGP funding was critical for the success of this project over the last two years. It allowed CROPS to offer a comprehensive training program and one-on-one support to a number of beginning specialty crop growers. They look forward to expanding the program in the future, with additional funding, to work toward meeting Secretary Vilsack's goal of 100,000 new farmers.

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Additional Information

Additional photos can be found on the CROPS website at http://www.communitycrops.org/workshops.

Project Title

Cooking and Storing Effects on the Antioxidative Components/Capacities of (Split) Great Northern Beans.

Project Summary

Dry edible beans are an important specialty crop with Nebraska state being the No. 1 and No. 2 US supplier of Great Northern Beans (GNB) and Pinto Beans, respectively. Studies have shown that dry edible beans contain natural antioxidative agents greater than or comparable to many types of fruits, vegetables, and cereals. These natural antioxidative agents, e.g., the phenolic compounds, have in turn been linked to multiple health benefits, including cardiovascular health and cancer prevention. Despite these attributes, split or cracked beans that are damaged during the harvesting process or post-harvest handling are discarded from the human food supply and used for animal feed. However, preliminary studies completed in the laboratories of Dr. Vicki Schlegel (Associate Professor, Department of Food Science and Technology, University of Nebraska Lincoln (UNL)) have shown that damaged GNB have similar antioxidant capacities compared to their whole bean counterpart but their physiochemical composition is slightly different. As a result, this difference could adversely impact the health promoting properties of split GNB under typical storage and cooking conditions. Therefore the purpose of this project was to compare the compositional profiles (total phenols / flavonoid,) and the antioxidant capacity of damaged (split) and whole GNB when subjected to various shelf-life (different temperatures) and cooking unit operations, (i.e., boiling, and baking). Understanding the effects of processing/storage conditions on the antioxidant properties of split GNB is needed to develop this currently-underutilized co-product for immediate human consumption and also for the niche but fast growing and highly economical functional food market. Nebraska will benefit from this type of research as a highly economic and value-added alternative for GNB will be determined.

A significant issue facing the US dry edible bean industry is the current price of competing field crops, such as corn, and the influx of dry edible beans from international sources, i.e., particularly GNB. As a result, the number of acres dedicated to dry edible bean has been declining in most US states (Table 1) with the largest decreases occurring in Texas followed by Colorado and Nebraska. Nebraska regions most affected by this decline include several counties located throughout our state, but particularly those in the Panhandle area. This geographic region has a clear need for higher paying jobs as 100% of these Nebraska counties have a median household income 22% below the state average. Additionally, population growth in these regions has been flat between 2000 and 2006 with the participating counties experiencing a 6% population decline in Nebraska. As the number of acres of dry edible bean production declines, so too does their economic viability, which, in turn, adversely affects the

rest of the economies in the region. Adding value to dry edible beans both by recapturing the value lost in the damaged dry edible beans and by promoting beans as a healthy dietary food system will help stabilize the dry edible bean industry in our state. This project was therefore important as it was the first to determine the antioxidative properties in damaged GNB in response to storage and cooking unit operations.

Project Approach

Below is a summary of the activities and tasks performed.

It was determined that major component analysis such as total proteins, fat, ash, and moisture would also be included in the studies associated with this project. This decision was made as major components can also be affected based on temperature, shelf life and cooking times, which in turn can affect the antioxidant levels. Based on receival of the beans, training of personnel, and release of the funding support, and final completion date of the project, (based on Nebraska Specialty Crop Block Grant contract (June 2011)), the new time line for the project was adjusted as shown in Table 1. Also, Specific Aim 1 extended into the 2nd Quarter, considering the increase in sample size and the addition of the new tests.

Table 1.

	2nd Quarter (Summer 2010)	2nd Quarter (Fall 2010)	3rd Quarter (Winter 2011)	May – June (2011)
• Training of Personnel	X			
• Specific Aim 1	X	X	X	X
• Specific Aim 2		X	X	X
• Specific Aim 3		X	X	X
• Specific Aim 4				X
• Specific Aim 5				X
• Composition of Final Report				

* Added to the project.

Shelf life studies for both the whole and split beans were initiated in August 2010 after personnel were trained and thus continuing throughout the fall (Sept-Dec), winter (Dec-April) and spring (May – June) duration of the project with anticipated sampling times of 0 (Sept), 1 (Oct), 3 (Dec), 5 (Feb), and 7 (Apr) months. With the notable exception of the lipid analyses (Specific Aim2) and antioxidant capacities, uncooked samples were initially characterized at the 0 month point, and 1 month, while the 3 month time point are currently in progress. As the technical requirements for the lipid extracts are more extensive than many of the other tests, such as the proximate and phenolic content, these time points

samples were stored appropriately so that all can be characterized in one setting. Moreover, the split and whole GNBs were boiled and baked at time point 0 and also again for the each temperature setting at time 1 month, and have undergone characterization. Collection of the samples, boiling and baking of the 3 month sample has also been completed. It must also be noted that lipid extracts are currently being stored appropriately for analysis for Vitamin E during the mid and/or end of this project due to the technical requirements of the tests.

4.) *Base Line Data*: (All samples were analyzed / extracted at least 3 times. These results represent the mean +/- std dev).

Tables 4a: Data for O month (Sept) time point

Table 4a.1 Proximate data for O month.

Beans	Moisture (%)	Ash (%)	Protein (%)	Lipid (%)	Carbohydrate (%)
Raw (Whole)	11.98 ± 0.50	3.87 ± 0.25	18.60 ± 1.71	1.12 ± 0.14	64.43 ± 0.91
Raw (Split)	12.61 ± 0.67	3.79 ± 0.23	18.69 ± 2.09	1.32 ± 0.14	63.72 ± 1.78
Boiled (Whole)	65.21 ± 0.05	0.96 ± 0.14	7.20 ± 0.70		
Boiled (Split)	73.24 ± 0.61	0.62 ± 0.18	6.49 ± 0.63		
Baked (Whole)	1.09 ± 0.17	4.75 ± 0.03	21.32 ± 0.10		
Baked (Split)	0.07 ± 0.14	4.91 ± 0.10	20.89 ± 0.38		

Table 4a.2 Total phenols / flavonoids for O month.

Beans	Phenols (mg/g)	Flavonoids (mg/g)	Antioxidant Capacity
Raw (Whole)	2.30 ± 0.28	0.33 ± 0.12	1543.2 ± 143.5
Raw (Split)	2.48 ± 0.36	0.31 ± 0.12	1713.5 ± 187.3
Boiled Bean (Whole)	0.96 ± 0.05	0.16 ± 0.01	
Boiled Bean (Split)	0.94 ± 0.03	0.13 ± 0.01	
Baked (Whole)	6.52 ± 0.06	1.13 ± 0.04	
Baked (Split)	5.13 ± 0.07	0.88 ± 0.03	

Tables 4b: Data for 1 month time point

Table 4b.1. Moisture data (in %) for 1 month (Oct) – different temperatures

Beans	4-10 ^{o}C	20-25 ^{o}C	40-50 ^{o}C
Raw (Whole)	12.78 ± 0.17	12.66 ± 0.06	7.01 ± 0.11
Raw (Split)	11.51 ± 0.18	12.49 ± 0.21	7.01 ± 0.11
Boiled (Whole)	65.54 ± 0.29	66.15 ± 0.99	59.65 ± 1.36

Boiled (Split)	72.64 ± 0.54	69.19 ± 0.57	69.19 ± 2.34
Baked (Whole)	0.92 ± 0.06	1.43 ± 0.05	0.65 ± 0.05
Baked (Split)	0.23 ± 0.14	1.05 ± 0.14	0.21 ± 0.12

Table 4b.2. Ash (in %) data for 1 month (Oct) – different temperatures

Beans	**4-10 ^{o}C**	**20-25 ^{o}C**	**40-50 ^{o}C**
Raw (Whole)	4.69 ± 0.16	4.58 ± 0.30	4.08 ± 0.18
Raw (Split)	4.61 ± 0.45	4.77 ± 0.03	3.86 ± 0.38
Boiled (Whole)	0.91 ± 0.02	0.94 ± 0.08	1.24 ± 0.06
Boiled (Split)	0.72 ± 0.09	1.01± 0.42	1.27 ± 0.07
Baked (Whole)	5.26 ± 0.43	4.40 ± 0.33	5.50 ± 0.08
Baked (Split)	5.16 ± 0.34	4.60 ± 0.18	5.49 ± 0.56

Table 4b.3. Total protein in (%) data for 1 month (Oct) – different temperatures

Beans	**4-10 ^{o}C**	**20-25 ^{o}C**	**40-50 ^{o}C**
Raw (Whole)	18.74 ± 0.24	18.67 ± 0.68	19.64 ± 0.12
Raw (Split)	18.16 ± 0.03	18.51 ± 0.13	19.63 ± 0.28
Boiled (Whole)	7.35 ± 0.18	7.31 ± 0.36	8.24 ± 0.11
Boiled (Split)	6.01 ± 0.24	6.40 ± 0.48	7.07 ± 0.28
Baked (Whole)	21.23 ± 0.22	21.60 ± 1.86	21.76 ± 0.34
Baked (Split)	20.98 ± 0.27	20.17 ± 0.26	20.70 ± 0.08

Table 4b.4. Total phenols in (mg/g) data for 1 month (Oct) – different temperatures

Beans	**4-10 ^{o}C**	**20-25 ^{o}C**	**40-50 ^{o}C**
Raw (Whole)	2.78 ± 0.06	2.84 ± 0.01	3.01 ± 0.20
Raw (Split)	3.30 ± 0.12	2.93 ± 0.07	3.01 ± 0.07
Boiled (Whole)	0.31 ± 0.06	0.48 ± 0.15	0.84 ± 0.07
Boiled (Split)	0.17 ± 0.00	0.06 ± 0.00	0.56 ± 0.06
Baked (Whole)	9.87 ± 0.22	10.24 ± 0.11	9.60 ± 0.43
Baked (Split)	7.87 ± 0.44	7.21 ± 0.09	7.26 ± 0.24

Table 4b.5 Total flavonoids in (mg/g) data for 1 month (Oct) – different temperatures

Beans	**4-10 ^{o}C**	**20-25 ^{o}C**	**40-50 ^{o}C**
Raw (Whole)	0.35 ± 0.01	0.40 ± 0.02	0.39 ± 0.02
Raw (Split)	0.41 ± 0.01	0.39 ± 0.01	0.39 ± 0.04

Boiled (Whole)	0.08 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Boiled (Split)	0.05 ± 0.00	0.04 ± 0.01	0.00 ± 0.00
Baked (Whole)	1.18 ± 0.01	0.98 ± 0.03	1.19 ± 0.06
Baked (Split)	0.93 ± 0.08	0.54 ± 0.01	0.82 ± 0.00

Qualitative: The objective of this proposal was accomplished by completing the specific aims listed below.

Specific Aim 1: To expose damaged and whole GNB to three storage conditions (0-4 ^{o}C, 22-25 ^{o}C, and 40-45 ^{o}C) for seven months followed by two cooking processes (boiling and baking). These temperatures were selected as dry edible beans are usually stored at room temperatures (22-25 ^{o}C) while the cooler (0-4 ^{o}C) and warmer (40-45 ^{o}C) temperature represent the best and worst case scenarios, respectively. Sampling occurred at time point 0, 1, 3, 5, and 7 months followed by cooking the samples via baking and boiling. (*Shelf life study and cooking unit operations were completed*.)

Specific Aim 2: To characterize and compare the lipid composition of damaged and whole GNB exposed to the different storage and cooking unit operations (Specific Aim 1). (As stated in the FY 2009 Annual Report, this specific aim was discontinued due to the low fat content in the beans. Instead, the beans were characterized for moisture, ash, and protein at each of the cited time points for each temperature and cooking operation. All tests were completed for samples collected at time point 0, 1, 3, and 7 months. Time point 5 samples are currently being characterized with anticipated time of completion of December 2012. Samples were placed in freezer after collection to prevent degradation. After collection of this data, statistical analysis will be performed. Refer also to Tables 1-3.)

Specific Aim 3: To characterize and compare the phenolic content of damaged and whole GNB exposed to the different storage and cooking unit operations (Specific Aim 1). Total phenols and flavonoids were determined to accomplish this Specific Aim. Again, time point 0, 1, 3, 7 months were completed in terms of testing, while time point 5 months is in progress with an anticipated completion date of Dec 2012. After collection of this data, statistical analysis will be performed. Refer to Figures 1, 3-4. Also, included in this Specific Aim but not part of the original proposal is the evaluation of the water from the boiled beans. These results are not shown as data is being reviewed.

Specific Aim 4: To determine and compare the antioxidative capacity of the lipid extracts and the phenolic extracts of damaged and whole GNB exposed to the different storage and cooking unit operations (Specific Aim 1). The antioxidative capacity was determined using the oxygen radical absorption capacity method. Time points 0, 1, 3 and 7 months are completed in terms of testing, while 5 is also in progress. However, after review of the data, several select points will be

retested as method was not functioning correctly. Therefore, only antioxidant data for Point zero is provided (Figure 2). After repeating some of the sample points at each time point, statistical analysis will be performed and will be provided in the final manuscript.

Specific Aim 5: To disseminate information to Nebraskans, i.e., specifically growers and the industries through various presentations and development of a web site for this information. This information has been disseminated to Nebraska growers by publishing article in "The Bean Bag, Issue 2011, 29: No 3". and to the Hasting Home Economics Women Society, Sept 26th through an oral presentation. A manuscript to be submitted in a peer reviewed journal is also in preparation. Also, the data collected to date was presented at the Undergraduate Creative Activities and Research Experience Seminar-April 14, 2011).

Quantitative: Whole and split GNB (Gemini line) were obtained from the same field and harvested in fall 2009. Beans were stored as received at -20 ^{o}C until start of the shelf life study (Fall of 2010). All results are shown as the analysis of three replicates +/- standard deviation. Outliers were tested with Grubb's test and rejected at the 95% confidence interval.

Table 1: Specific Aim 2 -- GNB moisture data (in % on a wwb) for 0, 1, 3, 7 months–different temperatures.

Month	Temp (^{o}C)	Raw (W)*	Raw (S)*	Boiled (W)	Boiled (S)	Baked (W)	Baked (S)
0	---	13.25 ± 0.09	11.95 ± 0.02	65.21 ± 0.05	73.24 ± 0.61	4.14 ± 0.12	5.56 ± 0.8
1	5-10	12.78 ± 0.17	11.51 ± 0.18	65.54 ± 0.29	72.64 ± 0.54	0.92 ± 0.06	0.23 ± 0.14
1	20-25	12.66 ± 0.06	12.49 ± 0.21	66.15 ± 0.99	69.19 ± 0.57	1.43 ± 0.05	1.05 ± 0.14
1	40-50	7.01 ± 0.11	7.01 ± 0.11	59.65 ± 1.36	69.19 ± 2.34	0.65 ± 0.05	0.21 ± 0.12
3	5-10	10.37 ± 0.27	9.46 ± 0.27	64.11 ± 0.28	67.76 ± 0.09	1.07 ± 0.04	0.19 ± 0.03
3	20-25	8.65 ± 0.29	8.43 ± 0.17	62.48 ± 0.28	68.61 ± 0.13	1.21 ± 0.06	ND
3	40-50	3.55 ± 0.19	3.40 ± 0.11	49.29 ± 1.60	68.05 ± 0.23	0.76 ± 0.06	ND
7	5-10	11.50 ± 0.14	11.39 ± 1.00	60.59 ± 0.27	64.21 ± 0.15	0.57 ± 0.07	0.13 ± 0.06
7	20-25	9.69 ± 0.69	9.24 ± 0.16	58.58 ± 0.11	63.24 ± 3.12	0.61 ± 0.04	0.15 ± 0.01
7	40-50	13.30 ± 0.07	9.10 ± 3.36	61.02 ± 0.17	64.66 ± 0.46	0.58 ± 0.12	2.56 ± 0.68

*W – Whole Beans, S – Split Beans, wwb – wet weight basis.
** 5 month time point is currently being tested.

Table 2: Specific Aim 2 -- GNB ash data (in % on a wwb) for 0, 1, 3, 7 months – different temperatures.

Month	Temp (^{o}C)	Raw (W)*	Raw (S)*	Boiled (W)	Boiled (S)	Baked (W)	Baked (S)
0	---	4.10 ± 0.11	4.12 ± 0.06	0.96 ± 0.00	0.62 ± 0.28	4.75 ± 0.03	4.91 ± 0.10

1	5-10	4.69 ± 0.16	4.61 ± 0.45	0.91 ± 0.02	0.72 ± 0.09	5.26 ± 0.43	5.16 ± 0.34
1	20-25	4.58 ± 0.30	4.77 ± 0.03	0.94 ± 0.08	1.01± 0.42	4.40 ± 0.33	4.60 ± 0.18
1	40-50	4.08 ± 0.18	3.86 ± 0.38	1.24 ± 0.06	1.27 ± 0.07	5.50 ± 0.08	5.49 ± 0.56
3	5-10	3.96 ± 0.44	4.10 ± 0.17	0.87 ± 0.14	0.75 ± 0.23	4.82 ± 0.10	4.96 ± 0.05
3	20-25	4.09 ± 0.17	4.38 ± 0.13	2.03 ± 1.83	0.73 ± 0.14	4.60 ± 0.27	4.63 ± 0.13
3	40-50	4.16 ± 0.25	4.49 ± 0.16	1.53 ± 0.19	0.61 ± 0.14	4.64 ± 0.08	4.91 ± 0.15
7	5-10	4.69 ± 0.06	4.69 ± 0.08	1.52 ± 0.05	1.34 ± 0.09	5.16 ± 0.06	5.18 ± 0.06
7	20-25	4.64 ± 0.07	4.76 ± 0.13	1.79 ± 0.02	1.15 ± 0.10	5.39 ± 0.11	5.50 ± 0.09
7	40-50	4.28 ± 0.09	4.46 ± 0.24	1.61 ± 0.02	1.44 ± 0.00	4.98 ± 0.05	5.02 ± 0.01

*W – Whole Beans, S – Split Beans, wwb – wet weight basis.

** 5 month time point is currently being tested.

Table 3: Specific Aim 2 -- GNB protein data (in % on a wwb) for 0, 1, 3, 7 months–different temperatures.

Month	Temp (^{o}C)	Raw (W)*	Raw (S)*	Boiled (W)	Boiled (S)	Baked (W)	Baked (S)
0	---	18.49 ± 0.14	18.11 ± 0.11	7.20 ± 0.70	6.49 ± 0.63	21.32 ± 0.11	20.89 ± 0.38
1	5-10	18.74 ± 0.24	18.16 ± 0.03	7.35 ± 0.18	6.01 ± 0.24	21.23 ± 0.22	20.98 ± 0.27
1	20-25	18.67 ± 0.68	18.51 ± 0.13	7.31 ± 0.36	6.40 ± 0.48	21.60 ± 1.86	20.17 ± 0.26
1	40-50	19.64 ± 0.12	19.63 ± 0.28	8.24 ± 0.11	7.07 ± 0.28	21.76 ± 0.34	20.70 ± 0.08
3	5-10	18.94 ± 0.41	18.54 ± 0.25	7.73 ± 0.50	6.78 ± 0.44	20.77 ± 0.41	20.90 ± 0.31
3	20-25	19.59 ± 0.21	18.65 ± 0.23	8.30 ± 0.49	7.22 ± 0.56	20.46 ± 0.24	20.34 ± 0.11
3	40-50	20.26 ± 0.43	20.23 ± 0.12	10.91 ± 0.50	6.40 ± 0.27	21.36 ± 0.08	20.44 ± 0.78
7	5-10	19.07 ± 0.39	18.62 ± 0.10	8.30 ± 0.43	7.16 ± 0.18	21.50 ± 0.20	21.53 ± 0.30
7	20-25	18.93 ± 0.24	19.06 ± 0.19	8.49 ± 0.43	6.73 ± 0.27	21.78 ± 0.40	21.38 ± 0.40
7	40-50	19.15 ± 0.18	18.71 ± 3.36	8.15 ± 0.59	6.41 ± 0.07	20.58 ± 0.59	19.85 ± 0.37

*W – Whole Beans, S – Split Beans, wwb – wet weight basis.

** 5 month time point is currently being tested.

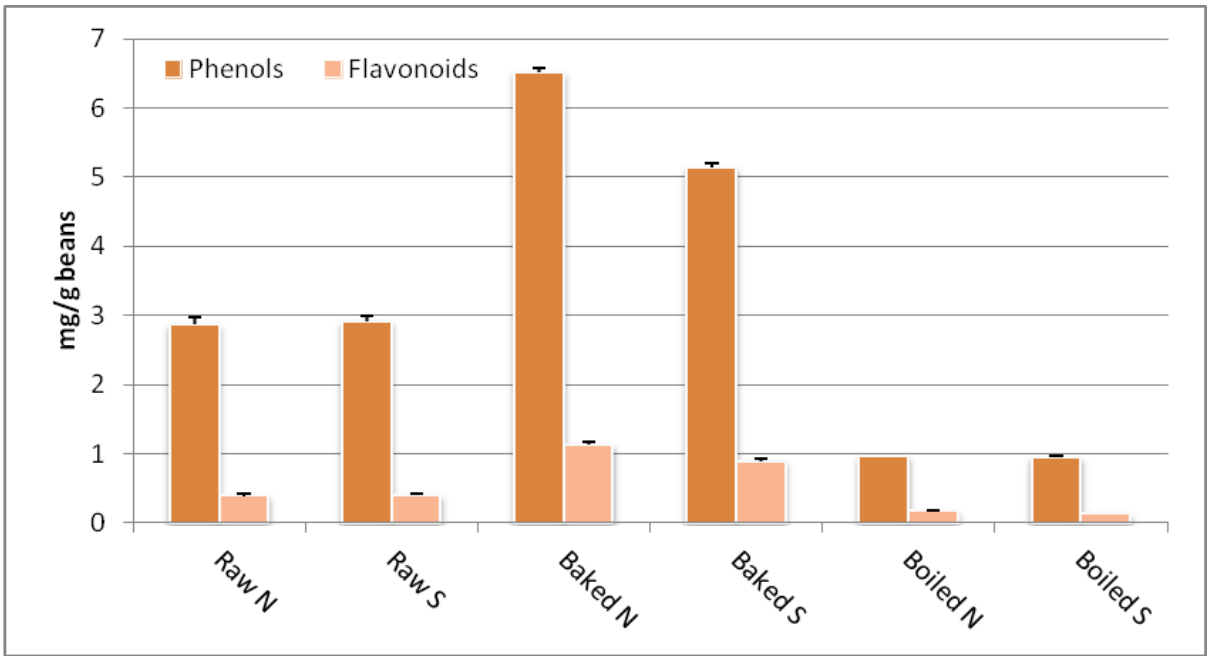

Figure 1: Specific Aim 3 -- Phenols and flavonoids at T = 0 for raw, baked, boiled, and water from boiled beans for normal (N) and split (S) beans. Data reported on a wet weight basis.

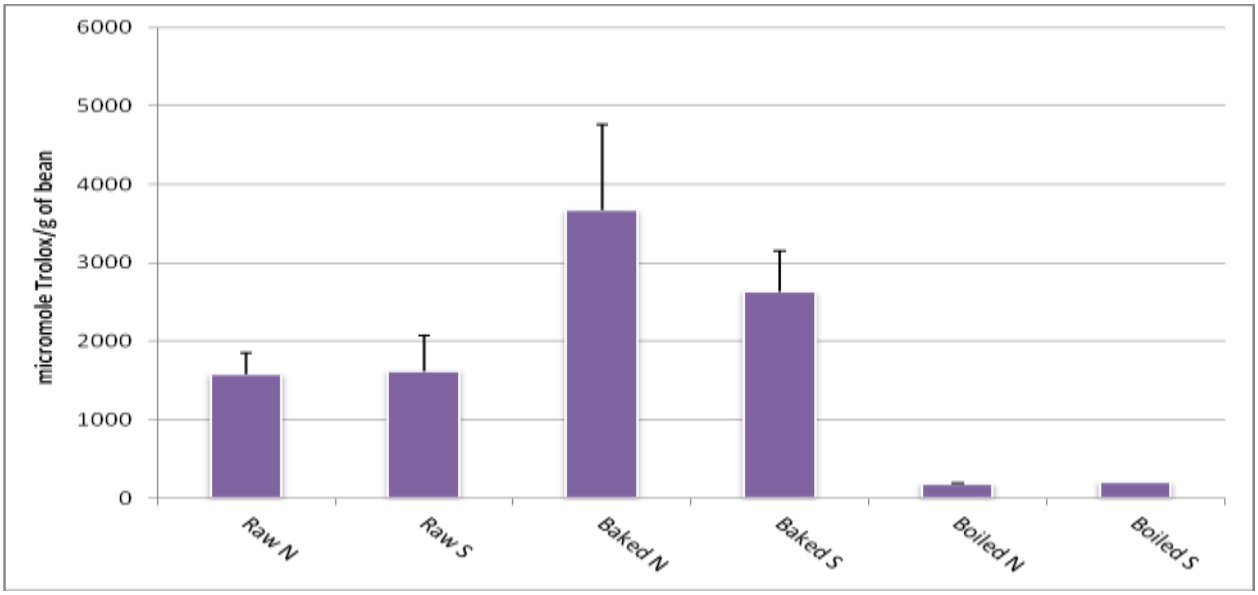

Figure 2: Specific Aim 4 – Antioxidant capacity for T = 0 for raw, baked, boiled, and water from boiled beans for normal (N) and split (S) beans. Data reported on a wet weight basis.

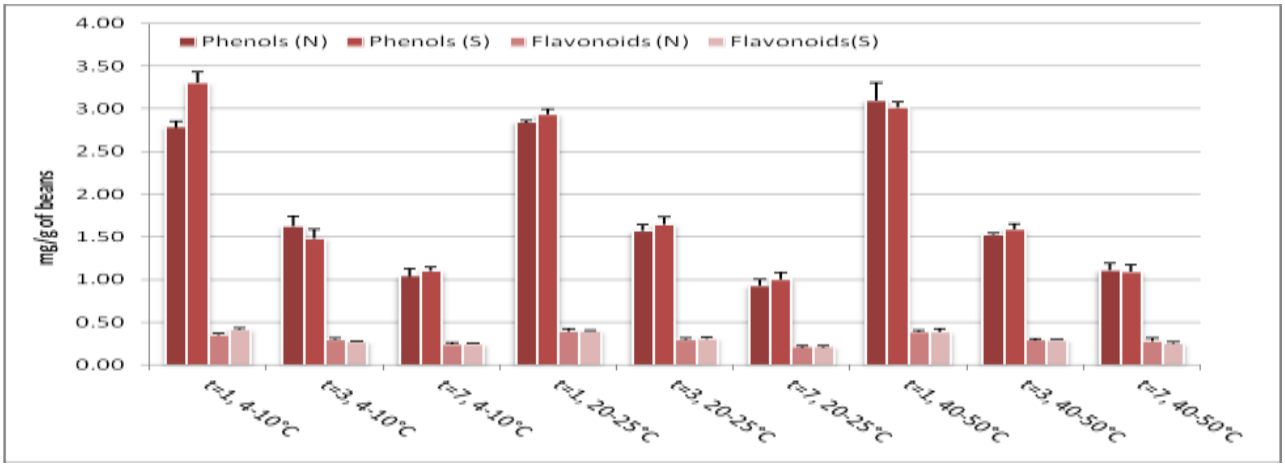

Figure 3: Specific Aim 3 -- Phenols and flavonoids at T = 1, 3, 7 months for RAW, normal (N) and split (S) beans. Data reported on a wet weight basis.

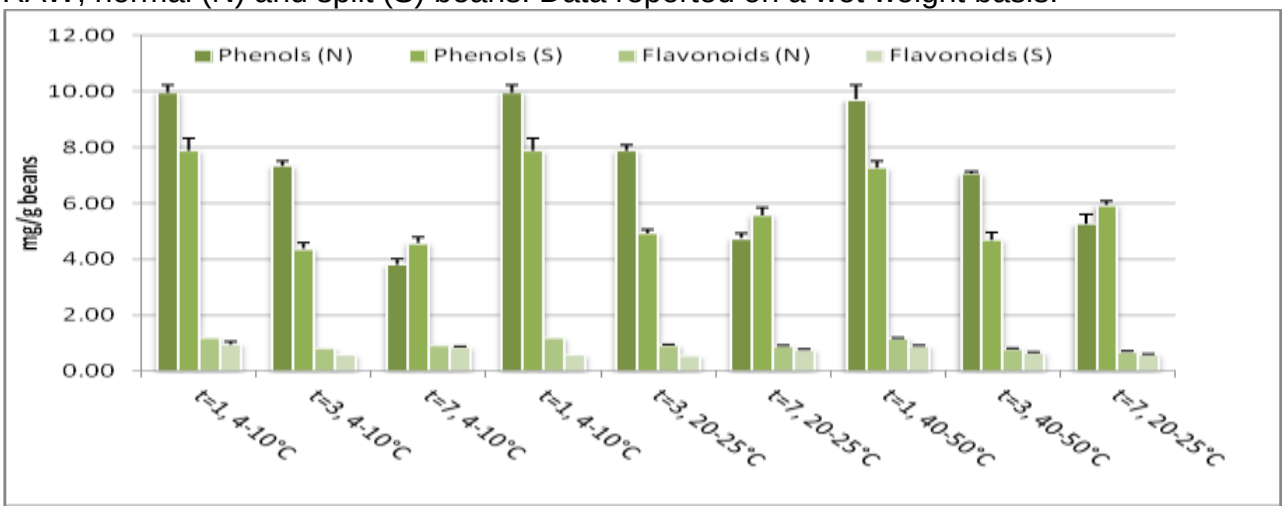

Figure 4: Specific Aim 3 -- Phenols and flavonoids at T = 1, 3, 7 months for BAKED Beans, normal (N) and split (S) beans. Data reported on a wet weight basis.

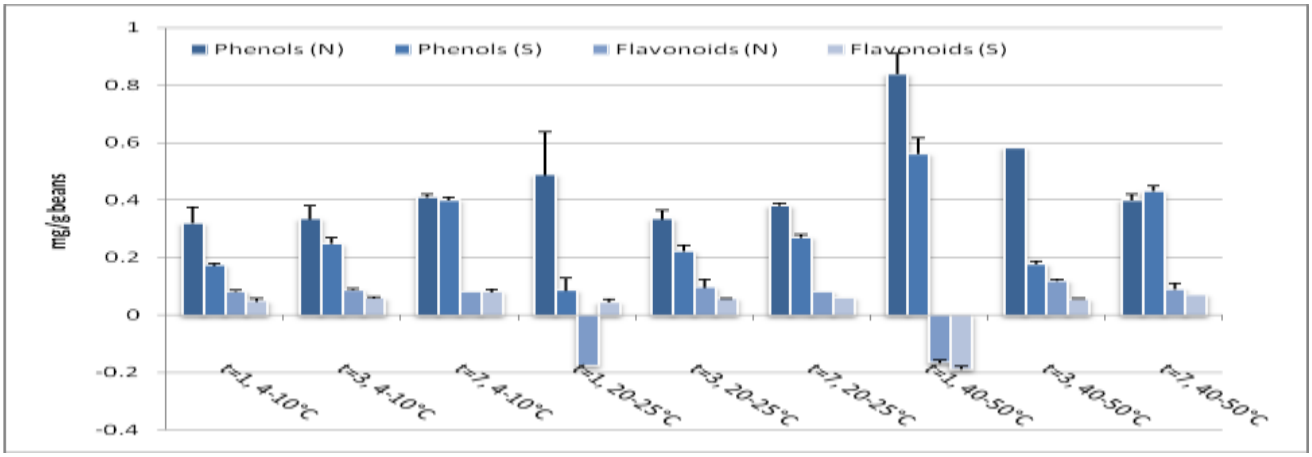

Figure 5: Specific Aim 3 -- Phenols and flavonoids at T = 1, 3, 7 months for BOILED Beans, normal (N) and split (S) beans. Data reported on a wet weight basis.

Significant results to date include 1.) moisture content of both whole beans and split beans decreased over time and temperature with overall lower content occurring in the split beans, 2.) moisture content of boiled split beans is consistently higher than whole beans but decreases for both types over time regardless of temperature, 3.) baked split beans also trended towards a loss of moisture over time compared to their whole bean counterpart. Ash and protein remained consistent between the split and whole bean regardless of temperature or storage time, albeit cooking operations did affect the results (mostly likely due to differences in moisture amounts). However, the most significant results were obtained from the phenolic experiments, which shown that the phenolics were impacted primarily by baking the baking process. This process impacted the phenols at T=0-3 but then stabilized while the whole beans continued to decrease to time point 7. Flavonoids were more stable in the raw beans across time and temperature with only slightly lower levels exhibited between split and whole for both cooking processes.

Favorable or Unusual Developments: The downward trend on antioxidant levels based more on duration of storage rather than temperature of storage was unexpected. However, effects on flavonoids were minimal as affected by temperature or storage duration, which is favorable outcome considering these agents exert the highest antioxidative responses.

Significant contributions and Role of Project Partners: Dr. Carlos Urrea (UNL Panhandle Research and Extension Center) grew and provided the beans for this project. Dr. Susan Cuppett's involvement provided needed equipment for the project. Dr. Vicki Schlegel has been providing continual oversight of the project to date.

Goals and Outcomes Achieved

Summary of activities completed: Refer to the Project Approach section of this report.

Comparison of actual accomplishments with expected measurable outcomes. As stated in the original proposal, the expected outcomes of this project were as follows.

- Important information relative to the health-containing components present in damaged GNB in response to storage and cooking effects would be generated. These outcomes were measured by monitoring the split beans against their whole bean counterpart starting at time point 0, which thus served as measures of performance. (*Accomplished. Refer to Specific Aims 1-4*).

- It was also expected that through the dissemination of these results to Nebraska bean producers, distributors, and food companies, we will be better positioned to promote and ultimately market damaged dry edible beans with known shelf lives as well as providing the fundamental information to develop bean derived health *promoting food products. (This is a long-term expectation, but information relevant to this project has already started to be disseminated (refer to Specific Aim 5)).*

- Other measureable outcomes included 2 research papers published in peer-reviewed journals and data needed to leverage funds from federal sources for continuing this work, i.e., linking potential bioactive components in other "split" dry edible beans to their antioxidant properties. (These outcomes are expected to be accomplished in next 6-12 months.)

Completion of expected outcome based on project baseline and final end point of project. Table 4 also shows the time line of this project with expected completion of each Specific Aim. The first bulleted outcome was accomplished via Specific Aims 1-4, albeit additional tests are being completed (specifically for Time Point 5) or are being repeated as they are suspect outliers. The second outcome is in progress by continuing to disseminate these results to our stakeholders (Specific Aim 5) and the third outcome is expected to be accomplished 6-12 months from the completion of this project.

Table 4. Time Line of Project.

	2nd Quarter (Summer 2010)	2nd Quarter (Fall 2010)	3rd Quarter (Winter 2011)	May – June (2011)	June-Sept (2012)
• Training of Personnel	X				
• Specific Aim 1		X	X	X	
• Specific Aim 2		X	X	X	
• Specific Aim 3			X	X	
• Specific Aim 4				X	
• Specific Aim 5				X	X
• Composition of Final Report					X
					X

Beneficiaries

Groups, operations, and other industry stake holders benefitting from this project. It is anticipated that multiple beneficiaries will be impacted from this research particularly producers and distributors of dry edible beans in the Nebraska Panhandle and other counties listed in Table 2. The companies with a presence in Nebraska who will benefit from the development of dry edible beans as a health promoting food system include large and small food based companies, such as Cargill, Archer Daniel Midlands, AGP, Abengoa, and Twin Valley Mills.

In addition to the long-range potential for private investment in the region by food and pharmaceutical manufacturers is the retention of dry edible bean dependent suppliers and service providers.

Outreach Programs: Results were presented at the annual UCARE seminar, (April 2011). Stakeholders present were mainly students (graduate and undergraduate) and UNL faculty (approximately 1,000 attendees). An oral presentation was provided to the Hasting Economics Ladies group (Sept 2011), which consisted of 10-15 women in the area. Preliminary results were presented in *The Bean Bag (Issue 2011, 29: No 3*), which has a circulation of approximately 3000 readers located in 24 states and Canada. Recipients include growers, landowners, politicians, other dry bean organizations, processors, advertisers, University personnel, et cetera.

Lessons Learned

Primary conclusion for the project is that both split beans and whole beans are affected by shelf life and cooking unit processing with split beans being affected predominantly during the first 3 months of storage.

A major unexpected outcome was that the phenolic group as a whole was impacted but flavonoids remained fairly stable.

A substantial amount of data was collected for these studies, which made it difficult to determine an optimal approach to organize the results into a cohesive presentation. However, by separating the data into two separate manuscripts, i.e., shelf life duration and temperature, a clearer understanding of the effects will be forthcoming. Nonetheless, the experimental approach was sound in that only one shelf life study had to be conducted to achieve multiple purposes. Sample storage under freezer and nitrogen purged conditions is always needed until all the data has been reviewed for the entire shelf life study. However, caution must be taken to anticipate changes relative to these sample storage conditions.

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Additional Information

A website has been developed (http://wheatdrybean.unl.edu) and information will be downloaded on the site after all samples have been analyzed.

Project Title

Irrigation and Nitrogen Management for Potatoes Under Reduced Water Availability

Project Summary

The drought of the past eight years in western Nebraska has magnified the problem of declining ground and surface water. Legislation in Nebraska to manage groundwater is having an impact and changing water allocations. For potato growers in the Southwest and Panhandle of Nebraska, it simply means less water and greater risk for yield and market quality. University of Nebraska research on major crops suggests that applying limited water provides more profit potential and has less impact on the local economy than reverting some land to dryland production (Schneekloth et al., 2001). Under limited irrigation, less water is applied than is required to meet full evapotranspiration demand. As a result, the crop will be stressed. The purpose of this project was to determine how to manage irrigation timing and nitrogen fertilization such that the resulting water stress has less of a negative impact on marketable potato yield. A project on corn, soybeans and wheat conducted at North Platte (Hergert et al, 1993; Klocke et al., 2004) showed that proper limited irrigation management did not reduce yield or income as much as would have been expected. Similar studies on potato have yet to be conducted.

Potatoes are highly sensitive to soil moisture and nitrogen due to a shallow, fibrous root system. Research on the effects of no-watering periods and irrigation scheduling on yield and canopy growth have been conducted with the aim of optimizing yield (van Loon, 1981). Studies reporting the effects of drought periods on misshaping of tubers were conducted on Russet Burbank (Painter and Augustin, 1976). More recently, some work on white-skinned varieties has been reported (Walworth and Carling, 2002).

No work has been done on chipping varieties such as Atlantic, an important variety grown in Nebraska under chip contracts. Research outside of North America has focused on drought-sensitive morphological parameters such as plant stature and leaf size (Deblonde and Ledent, 2000; Kashyap and Panda, 2003; Lahlou et al., 2003; Tourneux et al., 2003). A study in Turkey (Onder et al., 2005) reported that no more than a 33 percent reduction in irrigation could be tolerated by an early maturing potato under their semi-arid conditions. Trials compared irrigated plants versus extended water-limited periods. Reduced irrigation or mild stress for extended periods have not been studied.

This project is the second year of a multi-year study that began in the 2009 season (FY2008 Funds) and provides verification data. The three nitrogen levels were applied and the differential irrigation schemes initiated. The first and second phases of irrigation have been completed. Soil moisture and nitrogen,

and petiole nitrogen determinations, and growth and development measurements are complete. To account for annually varying weather conditions, this study needed at least two additional years to be completed. With data replication and verification, the results can be incorporated into the "Water Optimizer" program, a whole-farm, multi-cropping tool developed by Suppalla and Martin (http://real.unl.edu/h20) that is widely used by Nebraska producers but does not include potatoes. This project received $24,970 from the Fiscal Year 2008 SCBGP to conduct the first year of the project.

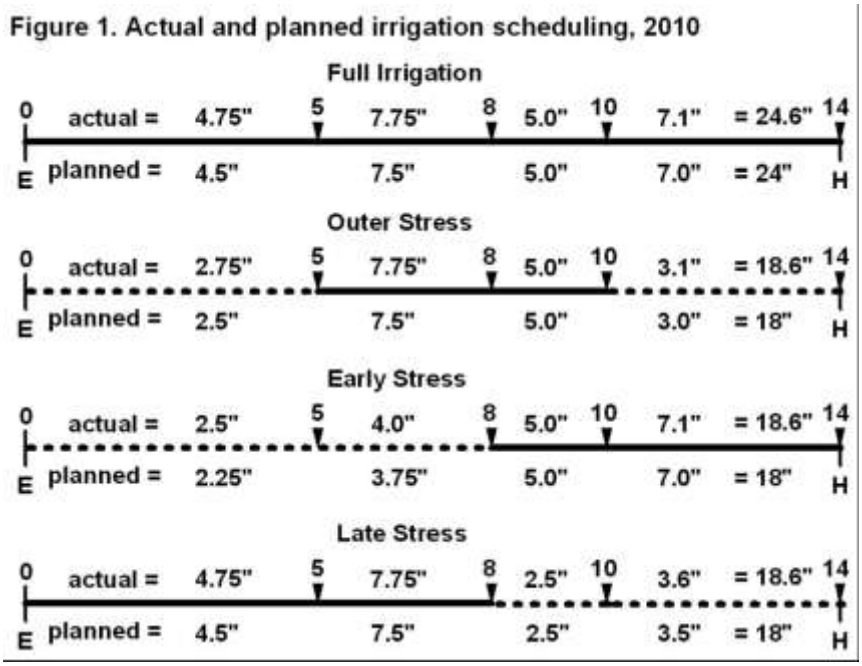
Project Approach

This is the second year of a four-year project. This project was planted on Saturday, May 22, 2010. Weather conditions delayed planting by a week compared to 2009. Goals and targets have all been met to date.

Potato cultivar Atlantic was exposed to reduced irrigation during three periods (first weeks after emergence, first five weeks plus last four weeks, and last six weeks) (Figure 1). Irrigation during these periods were reduced by half resulting in six inches less precipitation or 25% reduction from full irrigated plots (check). Controlled irrigation, adjusted for rain, was applied using a linear-move overhead (Lockwood) sprinkler irrigation system. Irrigation plots were divided into sub-plots based on nitrogen application, which was applied at 90, 150 or 210 lb/a. Nitrogen application was pre-plant, plant emergence, and early post-emergence. All plots were randomized and replicated four times. Major plots were 16 rows by 40 ft. Morphological readings on vine growth were taken at each irrigation period change. Also, soil moisture and nitrogen and plant nitrogen were determined at these times. Upon harvest, tubers were sorted by size and weighed. Premium sized tubers were scored for external and internal defects. Tubers were prepared and fried to determine cooking characteristics. Size, defects and cooking quality determined market compatibility. Below are the specific steps associated with this project.

Irrigation - Early June rains delayed planned irrigation by two weeks. The first irrigation was applied on June 29, 2010, and preceded according to the schedule adjusted for rain events as described in the proposal. The last irrigation was on September 10.

Figure 1. Actual and planned irrigation scheduling, 2010



Fertilization - Nitrogen fertilizer was applied as urea-ammonium nitrate (UAN) with a plot sprayer. The three applications were at planting (22 May), pre-emergence (4 June), and two weeks after emergence (26 June). Each application contained 30, 50, or 70 lb N/a to reach a total of either 90, 150, and 210 lb N/a. These represent N rates below recommended, recommended and above recommended level of N for 'Atlantic' potato. All applications went on schedule.

Soil and Tissue Analyses - Soil moisture was determined on soil from 0 to 8 inches and 8 to 16 inches below seed-piece placement using gravimetric technology. Determinations were made at each change in the irrigation regime schedule, 5, 8, 10 and 14 weeks after emergence (WAE). Daily change in soil dryness was measured using Watermark sensor technology. Along with soil moisture, soil nitrate-N was determined at the same depths and times from samples sent to Ward Lab in Kearney, Nebraska. At these times, petioles were collected and also sent to Ward Lab for determination of nitrate-N content in tissue. Collections went on schedule.

Growth and Development - Plant growth (canopy weight and size) and development (tuber initiation, flowering, and plant aging) were monitored during the season at times when irrigation scheduling changed (5, 8, 10, and 14 weeks after emergence). Measurements were taken as planned.

Yield Parameters – Vines were desiccated on September 14 (95 days after emergence) and potato tubers were harvested seven days later. Yields were determined by size grade, and tuber qualities were also processed.

Irrigation - Rainfall was unusually high in June (2010) that delayed differential irrigation to 29 June (Figure 1) resulted in 0.25 inches more precipitation than planned during the first five weeks after emergence. Rainfall variation was compensated by adjusting irrigation. Otherwise, irrigation went as planned

Soil Water - Fully irrigated plots contained 16-18% soil moisture or about 90% saturation. Stress for limiting water during the first eight weeks lowered soil moisture to 12% (Figure 2). Irrigating after five weeks, or in the case of early stress after eight weeks, brought soil moisture to 16 percent or greater. Soil moisture was not affected by N level.

Soil Nitrate-N below seed-piece - Limiting irrigation and imposing stress on plants early in the season, first 8 weeks, resulted in higher soil N compared to fully irrigated plots (Figure 3). This suggested a lower uptake of N by stressed plants. Soil N during the first eight weeks was lower in plots fertilized with 90 lb N/a than in plots fertilized with 150 and 200 lb N/a; after 10 weeks after emergence, there was no difference is soil moisture between N levels (data not shown).

Petiole Nitrate-N – When irrigation was limited early in the season for the first five or eight weeks, plants accumulated N in their petioles compared to unstressed plants (Figure 4). Fertilizing with N had no effect. Petiole N was the same when 150 and 210 lb N/a were added but petioles had less N when adding 90 lb N/a. Petiole N, however, seemed more affected by irrigation than by N fertilization.

Vine Growth and Development – The timing of tuberization and flowering were not affected by limiting irrigation. Flowering was complete between five and eight weeks after emergence (data not shown). Canopies weighed less and were small when water was limited (Figures 5 and 6).

Limiting irrigation decreased weight regardless of N fertility. Upon the return of irrigation, canopy growth partially recovered. Stem length was not affected by limiting irrigation or by N (data not shown). The leaf area index (LAI) at 8 WAE was very different with irrigation to that time. Unstressed plots (full and late stress) had higher LAI than the limited stress plots (outer), and significantly the lowest LAI was in the early stress plots which received 4 inches less irrigation than the outer stress plots and six inches less than the fully irrigated plots (Figure 7). No difference in LAI between irrigation treatments was present at harvest. Ground cover of fully irrigated plots was 85% at 5 WAE but those experiencing limited irrigation during the early weeks were at 65% ground cover (data not shown). By 10 WAE, ground cover was complete but plots experiencing stress during the first eight weeks (early stress) still had significantly less cover, at 80%, while all other plots were greater than 95% cover. At harvest, ground cover in early stress plots remained less than other plots and that of the outer stress plots was less than fully irrigated and late stress plots (data not shown).

Yield and Tuber Characteristics – Upon harvest, tubers were sorted by size and weighed. Premium sized tubers were scored for external and internal defects.

Tubers were prepared and fried to determine cooking characteristics. Size, defects and cooking quality determined market compatibility.

Goals and Outcomes Achieved

Trial was conducted exactly according to Work Plan as stated and all measurements were taken. All activities were completed. The outcomes described are based on the second year outcomes. The accomplishments fulfilled the goals set for this project. The following summarizes the results and conclusions of the expected measurable outcomes as outlined in the grant proposal.

Expected Measurable Outcome #1. The most distinctive outcome from the study will be to identify a specific seasonal period in which limiting irrigation will not adversely affect market yield of potato.

Yield was reduced by limiting water availability to potato in 2010 (Figure 2). The best period to limit water for the least harmful effect to yield was to limit water at the end of the season, 8 weeks after emergence (WAE) to 13 WAE. Increasing nitrogen application may partially relieve the yield loss. The worst period to limit water was from tuber initiation, 3 WAE, to mid tuber bulking, 8 WAE.

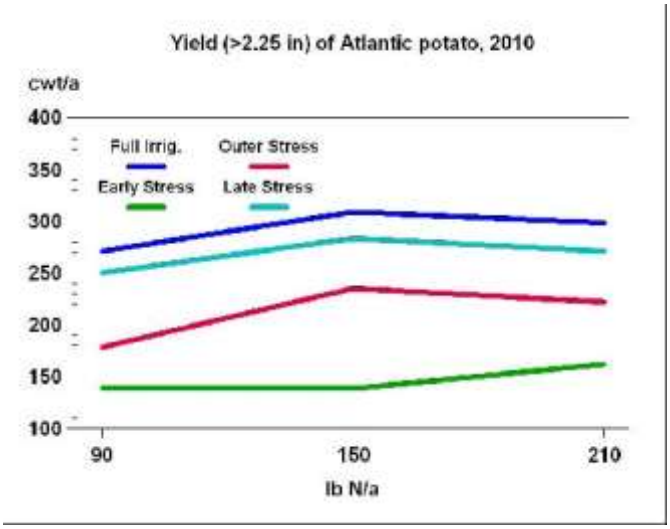


Figure 2. Yield

Expected Measurable Outcome #2. Market yield will be measured at the end of the season by harvesting total yield and then recording tuber size distribution, external and internal defects, and cooking characteristics.

Yield was determined based on tuber size distribution with emphasis on chipping (‘market”) size. These tubers were evaluated as to quality for frying. Several quality aspects, notably dry matter content and tuber shape were assessed and were not adversely affected by limiting water availability. However, chip color was

negatively and significantly affected when water was reduced between 5 and 8 weeks after emergence (Figure 3). Also, infection by common scab, a defect that eliminates market value of tubers, was significantly increased when plants were deprived of water between 5 and 8 weeks after emergence (Figure 4).

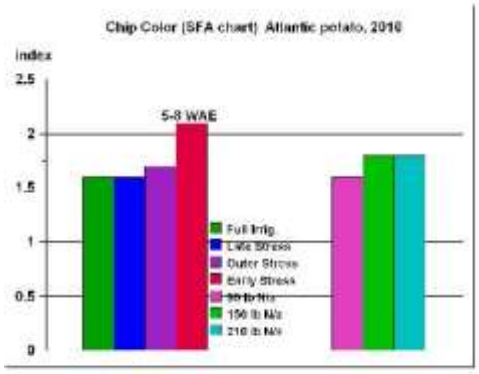


Figure 3. Chip Color

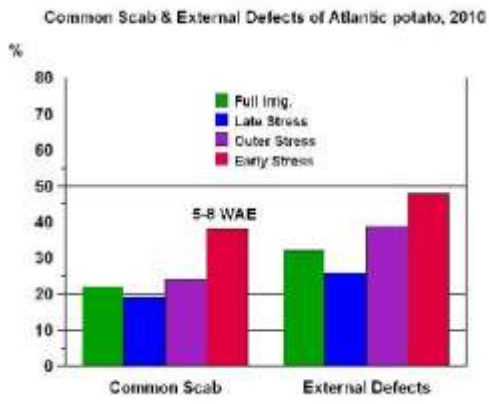


Figure 4. Common Scab and External Defects

Expected Measurable Outcome #3. Additional clear and measurable outcomes will be the determination of water use and timing, soil water depletion, nitrogen requirement and interaction during water shortages, and soil nitrogen changes. Changes in soil water and nitrogen, and petiole (in plant) nitrogen will be tracked at the start and end of water limitation periods throughout the season.

Fully irrigated plots contained 16-20% soil moisture or about 90% saturation. Irrigation regiments directly affected soil moisture (Figure 5) and were not affected by N level. Limiting irrigation and imposing stress on plants resulted in higher soil N compared to fully irrigated plots (Figure 6). This suggested a lower uptake of N by stressed plants. When fully irrigated, soil N is greater in 150 and 200 lb N/a fertilized plots than in those fertilized with 90 lb N/a and the soil N lasted longer (data not shown). When irrigation was limited, petioles contained higher N levels compared to unstressed plants, fully irrigated plots (Figure 7). Fertilizing with N had little effect. Petiole N seemed to be much more affected by irrigation than by N fertilization. The timing of tuberization and flowering were not affected by limiting irrigation; however, 90 lb N/a did delay flowering. By 8 WAE, flowering was 100% (full bloom) under all conditions (data not shown). Canopies were smaller, weighed less and had reduced leaf area when water was limited (Figures 8, 9 and 10). Limiting irrigation decreased size and weight regardless of N fertility. Upon the return of irrigation, canopy growth partially recovered.

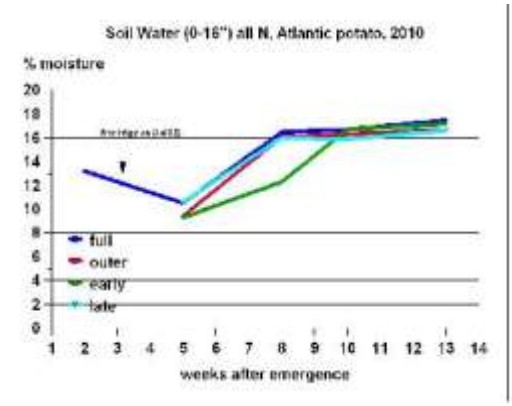


Figure 5. Soil Moisture

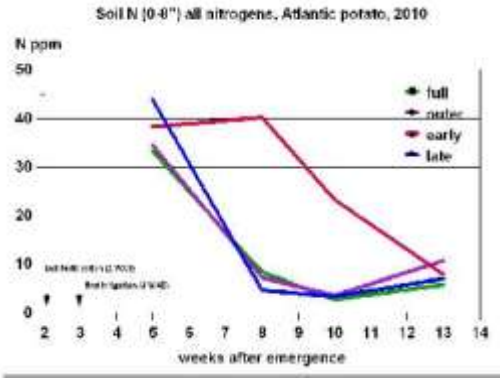


Figure 6. Soil Nitrogen

Figure 7. Petiole Nitrogen

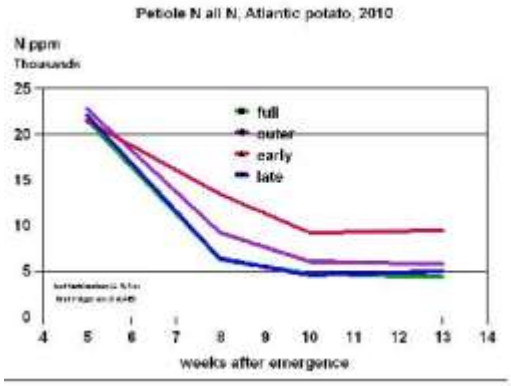
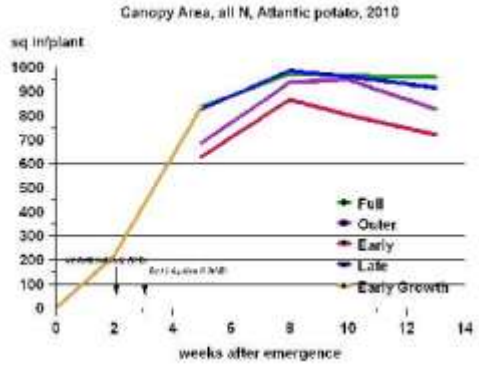


Figure 8. Canopy Area



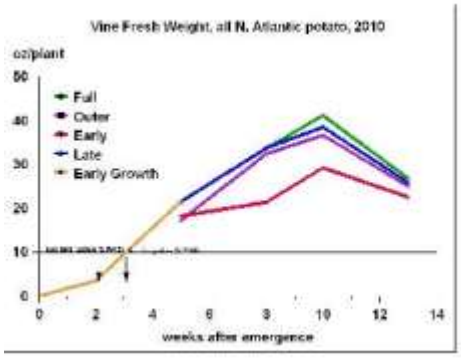


Figure 9. Canopy Fresh Weight

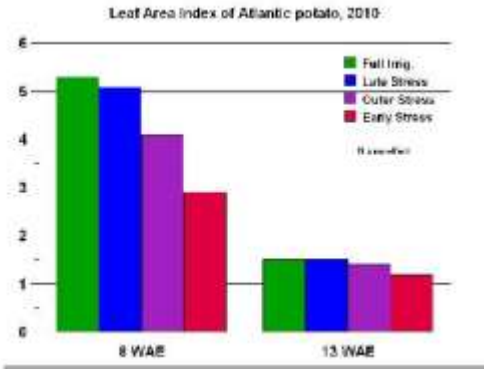


Figure 10. Leaf Area Indes

Expected Measurable Outcome #4. Rainfall and evapotranspiration will be monitored weekly throughout the season

Irrigation - Early June rains delayed planned irrigation by two weeks. The first irrigation was applied on June 29, 2010, and preceded according to the schedule adjusted for rain events as described in the proposal. The last irrigation was on September 10 (Figure 1).

Rainfall was unusually high in June (2010) that delayed differential irrigation to 29 June (Figure 1) resulted in 0.25 inches more precipitation than planned during the first five weeks after emergence. Rainfall variation was compensated by adjusting irrigation. Otherwise, irrigation went as planned

Expected Measurable Outcome #5. An economic evaluation of the market yield price based on Frito-Lay contracts, agronomic inputs, and savings in irrigation and fertilization costs will be tabulated at the end of the project.

This is a long-term outcome, which will be conducted at the conclusion of this study in 2013.

Beneficiaries

The results and findings of this study were disseminated to the target audiences.

This study is ongoing and dissemination of information will continue as additional data is obtained. The target audiences were potato growers and scientists.

Below is a list of the presentations delivered as they relate to this project.

1. Nebraska Potato Development Committee in March, 2011 in Kearney, NE - target audience = 30, Nebraska potato growers and representatives of the Nebraska Department of Agriculture.

2. NCERA 211 ("Potato Research and Extension Program") in March, 2011 in Minneapolis, MN target audience = 60, north-central region potato growers, potato scientists and USDA representatives.

3. Central Great Plains Working Group in August 2011 in Fort Collins, CO - target audience = 50, researchers, from U. Nebraska, Colorado State U, Kansas State U, U Wyoming, South Dakota State U., and USDA-ARS interested in limited irrigation in crops in the Great Plains region.

4. The Potato Association of America in August 2011 in Wilmington, NC - target audience = 300, USA and Canadian potato growers, University, USDA-ARS and Ag-Canada researchers, and representatives from potato-producing countries such as the UK, Netherlands, and Mexico.

5. Internet - target audience = 8,000. All potato growers, researchers and government representatives world-wide. The 2009 and 2010 data are currently being prepared to be uploaded onto the principal investigator's website, *Potato Education Guide.* Completion is expected in winter of 2011/2012.

The quantitative data that concerns the potato community the most are related to yield, tuber quality, and cooking characteristics as these were affected by periods of limited irrigation (Figures 2, 3 and 4). Current policies of Frito-Lay and other chip manufacturers is that of an "accept" or "reject" criteria on loads of chipping potatoes. When tuber quality is below the accepted level, the entire potato load (semi-truck), is refused. Therefore, a minimum number of poor tubers per shipment is essential. The other quantitative data are critical to understanding soil water and nitrogen changes (Figures 5 and 7), and the health and growth of the plant (Figures 8, 9, & 10).

Lessons Learned

The second year's data verified most of the tentative conclusions of the previous year. When limiting water supply, it is least deleterious to withhold water toward the end of the season, from mid bulking (8 WAE) to harvest, and worst when withheld from tuber initiation (3 WAE) to early tuber growth (8 WAE). It appeared that applying nitrogen could partially mitigate the yield loss. Based on yield, tuber quality and chip color, the worst case scenario was withholding water between 5 and 8 WAE.

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Additional Information

None.

Project Title

Development of an Internet-Based Pesticide-Sensitive Crop Locater

Project Summary

Non-traditional agricultural crops, including fruits, vegetables, nuts, and berries, are increasingly becoming more visible across the landscape, due to expanding markets and other economic forces. Consumers are choosing to buy these products directly from farmers in their local area. This demand for locally grown produce is driving consumers to farmers' markets, roadside stands, and U-pick operations across the nation. This, in turn, is creating more demand and, thus, more specialty crop farms and growers. NDA's Pesticide Program has seen an increase in the number of complaints filed against pesticide applicators that allegedly spray or drift product onto sensitive crops. Specialty crops, including fruits and vegetables, are highly sensitive to many of the more commonly used herbicides. Consequently, the increase in the production of Nebraska fruits and vegetables has created tension between neighbors who grow traditional agricultural crops and those who raise specialty crops and other pesticide sensitive crops. Growth regulator herbicides are the main causes of crop injury, and these active ingredients are found in many pesticide products labeled for agriculture.

Given the potential for growth in Nebraska's fruit and vegetable industry and other specialty crops, the number of complaints of alleged crop injury due to pesticides has the potential to increase. The main objective of this project was to raise awareness of nontraditional agriculture crops in the mind of pesticide applicators, reduce the potential for crop injury and subsequent economic harm, and reduce the number of pesticide complaints involving specialty crops requiring NDA investigation.

Project Approach

The Nebraska Pesticide Sensitive Crop Locater web site (http://www.agr.ne.gov/division/bpi/pes/psci.htm) was introduced to the public in November 2009. The Locater consists of a searchable tabular database of pesticide sensitive crop locations, as well as an interactive map for finding pesticide sensitive crops in Nebraska. Both can be used by pesticide applicators to locate pesticide sensitive crops near their planned application sites.

Promotion of the project to growers of specialty crops – the major beneficiary of the project – is largely dependent on partners who work or interact directly with them. NDA maintains an e-mail list of partners, including grower organizations and government agencies, whereby project updates and requests to promote the project are sent. This correspondence – twice per year – is timed with the development of an update for the pesticide applicator audience in NDA's

At the beginning of the project, an initial e-mail announcement was sent by NDA to eight grower groups with a request to publicize this service to their membership via newsletter, e-mail messages, etc. This message encouraged growers to log into the system and input their crop location information. This message was also sent to approximately five pesticide and agriculture industry groups, and six local, state, and federal agencies, requesting help in promoting the project to farmers and other pesticide applicators. Appendix A lists all of the recipients of the initial announcement and subsequent updates about the project.

In addition, a direct mailing was sent to 220 Nebraska organic producers and 540 Nebraska fruit/vegetable growers from mailing lists compiled by NDA. NDA also sent letters to approximately 450 aerial applicators, informing them of the service and requesting they consult the database frequently. This included both instate and out-of-state applicators, because NDA has seen increasing numbers of out-of-state applicators with the rise in commodity prices, as well as an increase in complaints involving non-resident pilots.

For other pesticide applicators, the University of Nebraska Pesticide Safety Education Program included NDA's Protecting Nebraska's Pesticide Sensitive Crops brochure in the training packet for approximately 6,000 private pesticide applicators. NDA included articles in both the winter and summer 2010 issues of the Pesticide and Noxious Weed Newsletter which is sent to approximately 8,000 commercial and non-commercial applicators in the agricultural, right-of-way, and ornamental and turf categories. These audiences are the target market for applicators in this project. Appendix B lists the meetings, presentations, newsletters, web sites, direct mailings, and other media used to promote the Pesticide Sensitive Crop Locater.

In February 2011, an e-mail invitation was sent to approximately 500 pesticide sensitive crop growers, using e-mail addresses compiled from USDA National Organic Program, NDA organic transition program, and NDA specialty crop grower and farmer market databases.

NDA developed a 'Locater' business card (Figure 1) to be distributed to both growers and pesticide applicators. Approximately 6,000 business cards have been distributed to various partners and individual growers during the project period. Partners were asked to incorporate the business card in their own newsletters, as well. NDA personnel attended various trade shows, farm shows, and fairs where Locater brochures and business cards were available. These included the Nebraska Power Farming Show (December 2010), Great Plains Vegetable Growers Conference (January 2011), the Nebraska Ag Classic (combined commodity board conference), Governor's Agri/Eco-Tourism Workshop (February 2011), Governor's Ag Conference (March 2011), Husker Harvest Days (September 2011), the Nebraska State Fair (August 2011), and AKSARBEN (September 2011).

Figure 1. NDA Pesticide Sensitive Crop Locater business card used to promote the web site.

Locater web site information was also distributed to the pesticide applicator audience. NDA publishes the *Pesticide and Noxious Weed Newsletter* twice per year. This is mailed to approximately 11,000 people, including all commercial applicators (9,000), pesticide dealers (1,200), and numerous university and government partners (~1,000). These articles are often used by agricultural industry groups in their own newsletters and web sites, too (see Appendix B).

NDA also licenses approximately 21,000 private applicators (farmers); however, there is no newsletter specifically targeting this audience. NDA works cooperatively with the University of Nebraska Pesticide Safety Education Program (PSEP) which, through county Extension Educators, annually provides applicator training sessions for all applicators needing NDA's license. Applicators are certified for three years, so they receive training through this system every third year. Table 1 provides a breakdown of the applicator audience receiving training through the PSEP system in 2011.

Training Session	Attendance
Private Applicators (farmers)	10,560
Crop Production Clinics (ag plant category)	1,631
Commercial Applicator recertification - general standards video (all commercial applicators)	1,295

Table 1. Number of private and commercial pesticide applicators attending University of Nebraska Pesticide Safety Education Program sessions where the Pesticide Sensitive Crop Locater was discussed.

Information on the Locater web site was included in the training guides given to private applicators, and presentations were given at both the Crop Production Clinics for the commercial Ag Plant category, and all general standards recertification sessions for the other commercial applicators. An example of one presentation can be seen at http://cpc.unl.edu/2011mm.cfm by selecting the Pesticide Safety and Education tab under "IPM Topics," then selecting the

"Environmental Safety and Pesticides presentation." The topic of the Pesticide Sensitive Crop Locater occurs within the first minute of this presentation.

In addition to the discussion topic, applicators attending select sessions were surveyed about their knowledge of the Locater. A discussion of these results is included in the Goals and Outcomes section of this report.

Goals and Outcomes Achieved

Outcomes, benchmarks, and goals were established for this project in the work plan. These are provided below with a measure of performance, if known, for comparison.

1st Year

Expected Measurable Outcome #1: A substantial increase in the number of grower data available in the pesticide sensitive crop database.

Benchmark 1	Goal 1	Measure 1 (End of Year 1)
100 database records representing approximately 100 distinct vineyards (farms)	Locations in the database will represent 80 percent of farms growing specialty and other pesticide sensitive crops (using the 2007 Census estimates), or approximately 1,000 farms (counting distinct individuals or companies separately)	160 individual companies or farms or 16 percent of goal 1

and/or

Benchmark 1a	Goal 1a	Measure 1a (End of Year 1)
100 database records representing approximately 100 distinct crop/field locations	1,500 database records, representing 10- to 160-acre fields (this is highly dependent on grower perception and interest)	245 database records or 16 percent of goal 1a

The sensitive crop database has grown since its debut and web activity by growers has been tracked. Table 2 shows the breakdown of the various crop types that are now contained in the database, compared to approximately 100 records for vineyards only when the project was made public. Figure 2 shows the locations of Internet providers of people who have accessed the grower data

input page of the Locater web site. It is assumed that most of these people are actual growers, though it could be people simply browsing the web site.

Crop Type	Total
Fruit or Vegetables	20
Grapes	109
Honey	12
Nursery (ornamental plants, plants for seed, flowers/cut flowers, etc)	7
Orchard (trees for fruit/nuts)	3
Organic	73
Other	21
Grand Total	245

Table 2. Crop type categories and record counts contained in the Locater database as of September 30, 2010.

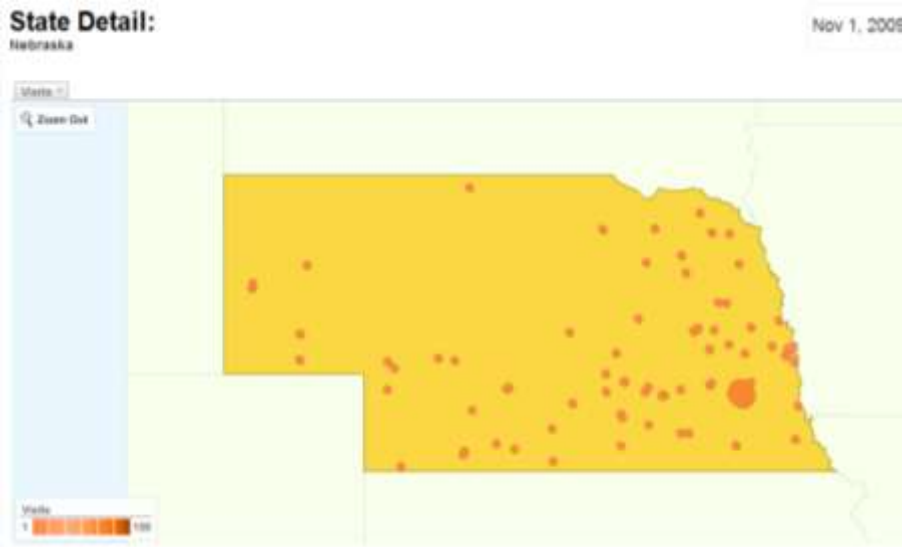

Figure 2. Cities where Nebraska Internet Providers are located.

Between November 1, 2009, and September 30, 2010, approximately 486 web site visits were made by people with Nebraska Internet providers to the sensitive crop data input page, which growers use to add their location information. Figure 2 shows the cities where Nebraska Internet Providers are located. Administrative web site hits from the State of Nebraska and the University of Nebraska are subtracted from the total. (web tracking provided by Google Analytics)

Expected Measurable Outcome #2: A reduction, or at least no significant increase, in the number of pesticide complaints resulting in a violation of the Nebraska Pesticide Act.

Benchmark 2	Goal 2	Measure 2 (End of Year 1)
An average of three annual complaints involving pesticide sensitive crops over the last nine years, ranging from 0-7 complaints per year.	No significant increase in the number of complaints received annually, and a decrease in the number of violations resulting from these complaints.	FY10, NDA received two formal pesticide complaints and several inquiries by pesticide sensitive crop growers.

Expected Measurable Outcome #3: A substantial interest on the part of applicators in viewing the database and/or mapping service.

Benchmark 3	Goal 3	Measure 3 (End of Year 1)
An estimate of 25,000 to 50,000 annual pesticide applications potentially affecting pesticide sensitive crops.	The pesticide Sensitive Crop Locater will be accessed for at least half of the estimated number of applications, or 12,800 times annually, once the project is implemented, promoted, and grower data increases.	The tabular database search page was accessed 520 times by people having Nebraska service providers or 4% of Goal 3.

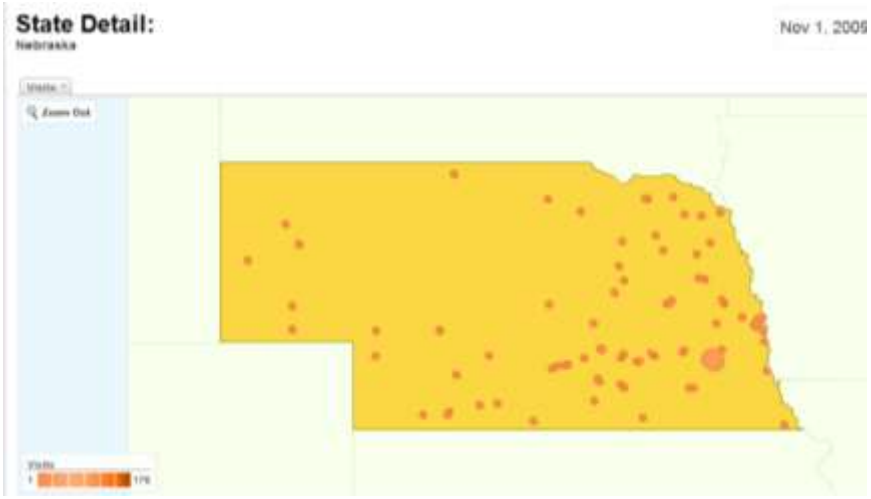

Figure 3. The locations of the Internet providers of people accessing sensitive crop search page in Fiscal Year 2010.

Figure 3 shows the locations of the Internet providers of people accessing sensitive crop search page in FY 2010. It is assumed most of these people were pesticide applicators, although some could be attributed to growers checking to see if their locations were being displayed or people simply browsing the web site.

Between November 1, 2009, and September 30, 2010, approximately 520 web site visits were made by people with Nebraska Internet providers to the sensitive crop data search page, where applicators can determine if sensitive crops are near their application area. Administrative web site hits from the State of Nebraska and the University of Nebraska are subtracted from the total. (web tracking provided by Google Analytics)

Benchmark 3a	Goal 3a, 3b, & 3c	Measure 3a, 3b, & 3c (End of Year 1)
Subjective evidence that there is an interest on the part of applicators, based on requests for such information over the last several years, from both applicators and growers.	Approximately 80 percent of applicators surveyed will have heard about the Locater; 60 percent of those surveyed will have accessed the web site; and Of those stating sensitive crops are nearby, 60 percent will indicate taking extra precautions.	No measure, yet, for comparison; however, a survey will be conducted by UNL Extension at private and commercial pesticide applicator training sessions beginning in January 2011.

Expected Measurable Outcome #4: A complete and spatially accurate dataset will be created that will be used by researchers and commodity organizations as the stepping stone to agronomic research.

Benchmark 4	Goal 4	Measure 4 (End of Year 1)
Currently, agronomic research of the favorable site conditions needed for specialty crops is done on small scales because no statewide	At least one study will be conducted/published using data from the Locater as the basis for spatially evaluating agronomic conditions for specialty or other pesticide sensitive crops.	Ting Chen. Unpublished Master's Thesis: Using a Geographic Information System to Develop a Vineyard Suitability Model for Selected Wine Grape Cultivars in Nebraska. This paper will be finished in

database exists.		the near future.

2nd Year

Outcomes, benchmarks, and goals were established for this project in the Work Plan. These are provided below with a measure of performance, if known, for comparison.

Expected Measureable Outcome #1: A substantial increase in the number of grower data available in the pesticide sensitive crop database.

Benchmark 1	Goal 1	Measure 1 (End of Year 2)
100 database records representing approximately 100 distinct vineyards (farms)	Locations in the database will represent 80 percent of farms growing specialty and other pesticide sensitive crops (using 2007 Census estimates), or approximately 1,000 farms (counting distinct individuals or companies separately)	190 individual companies or farms or 19 percent of Goal 1

and/or

Benchmark 1a	Goal 1a	Measure 1a (End of Year 2)
100 database records representing approximately 100 distinct crop/field locations	1,500 database records, representing 10- to 160-acre fields	286 database records or 19 percent of Goal 1a

Although the number of database records have newly tripled since the web site was first publically announced, it is somewhat surprising that Goals 1 and 1a have not been achieved. Reasons for the slow start and lethargic numbers are unknown. A majority of the targeted producers were informed via NDA's direct mailings to increase their awareness of the system and its potential benefits (Year 1). These mailings were conducted during the winter months when farm planning and spring preparations traditionally take place. NDA assumes there may have been a large percentage of growers taking vacations at that time, and it may simply take more than one exposure to reach the target audience so they clearly understand the system's benefits. An e-mail promotion was used in February 2011 (Year 2), and sent to individuals from a variety of databases. Web site activity increased shortly after both of these promotions (Figure 2).

Figure 4. A web site chart illustrating the hits for grower data input from October 1, 2009, through September 30, 2011 (20 visits is the upper bound of the y axis).

The above chart's two largest spikes correspond to direct mailings to specialty crop growers in February 2010 and February 2011. This chart shows all web hits, and has not been filtered for administrative hits from State of Nebraska or University of Nebraska sources.

The below table shows the breakdown of the various crop types that are now contained in the database, compared to approximately 100 records for just vineyards when the project was initially launched.

Crop Type	Total
Fruit or Vegetables	32
Grapes	117
Honey	13
Nursery (ornamental plants, plants for seed, flowers/cut flowers, etc.)	8
Orchard (trees for fruit/nuts)	6
Organic	85
Other	25
Grand Total	286

Table 3. Crop type categories and record counts contained in the Locater database as of September 30, 2011.

The image below is a screen shot of the Pesticide Sensitive Crop Locater mapping page, showing a statewide view of the types and locations of sensitive crops from Table 3.

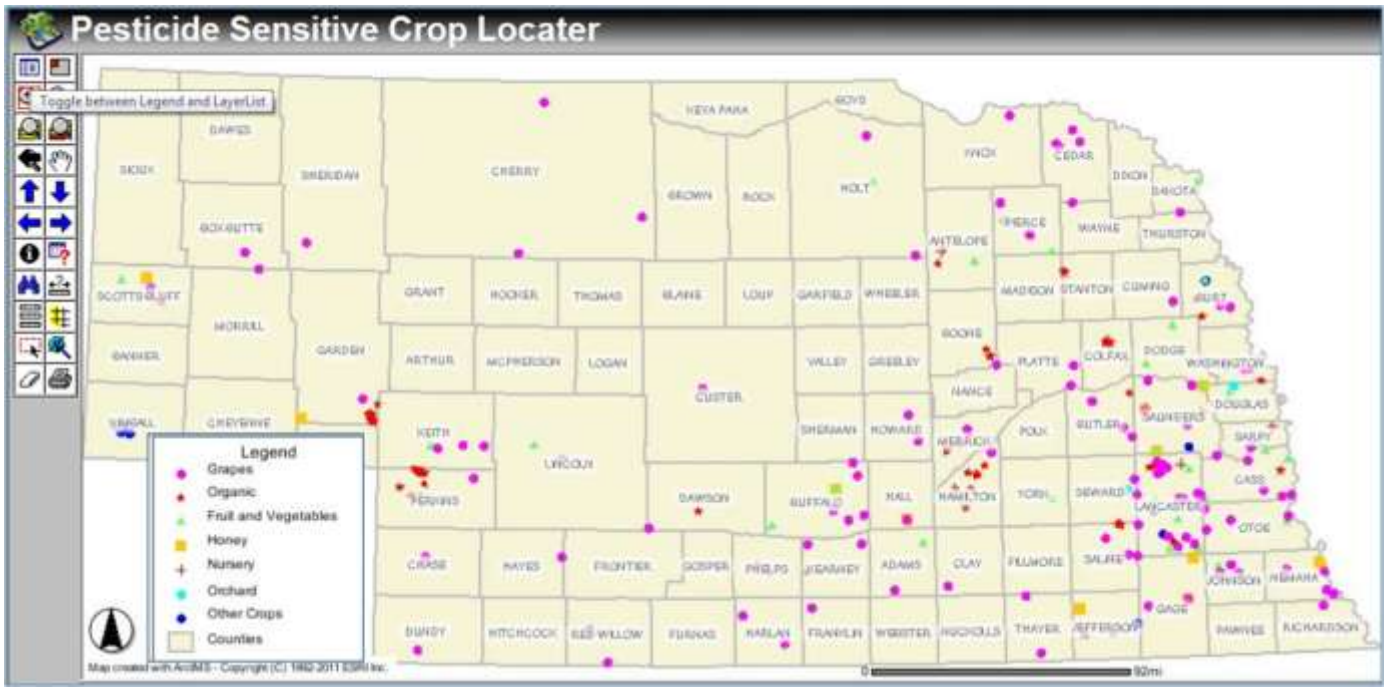

Figure 5. An image from the Pesticide Sensitive Crop Locater mapping page showing locations and categories of pesticide sensitive crops found in the Locater database.

Approximately 1,146 total site visits were made to the grower data input page in the last two years, including people from out of state and across the world (Figure 4; web tracking provided by Google Analytics). When administrative site hits from the State of Nebraska and University of Nebraska were subtracted, as well as non-Nebraska hits, a total of 637 web hits were recorded. It is assumed that most of these were by actual growers, although many were likely people simply curious about the web site. (It is important to note the group of spikes near the left of Figure 4 coincides with the announcement of the Locater to pesticide applicators in NDA's Pesticide and Noxious Weed Newsletter.) This newsletter is distributed to many government partners, including USDA FSA/NRCS offices and Extension offices, some of which were noted in the list of Nebraska web hits during this time.

Expected Measureable Outcome #2: A reduction or, at least, no significant increase in the number of pesticide complaints, resulting in a violation of the Nebraska Pesticide Act.

Benchmark 2	Goal 2	Measure 2 (End of Year 2)
An average of three annual complaints involving pesticide sensitive crops	No significant increase in the number of complaints received annually, and a decrease in the number of violations resulting from these complaints.	FY11, NDA received **9** formal pesticide complaints and several inquiries by pesticide sensitive crop growers.

over the last nine years, ranging from 0-7 complaints per year.		

In theory, as the number of sensitive crop growers in the database increase (including specialty crop growers), pesticide applicators will become accustomed to using the web site as a resource of information. As a result, it is believed that complaints about pesticide drift should decrease. However, because of differences in categorizing these types of complaints over the years and the difficulty of filtering these specific cases from the data, confidence in the numbers of complaints each year may be lacking. In addition, it is apparent this is a project "in progress," so reaching all of the growers and applicators about the benefits of the project will take time. The number of complaints may even increase over the short term, as specialty crop growers learn of the project and become aware of NDA's pesticide enforcement program. It is apparent from several grower conversations that they were unaware of NDA's authority to regulate and enforce pesticide use prior to implementation of this project.

Expected Measureable Outcome #3: A substantial interest on the part of applicators in viewing the database and/or mapping service.

Benchmark 3	Goal 3	Measure 3 (End of Year 2)
An estimate of 25,000 to 50,000 annual pesticide applications potentially affecting pesticide sensitive crops.	The pesticide Sensitive Crop Locater will be accessed for at least half of the estimated number of applications, or 12,800 times annually, once the project is implemented, promoted, and grower data increases.	The tabular database search page was accessed 300 times by people having Nebraska service providers or 2% of Goal 3.

Approximately 1,186 total visits by 729 individuals were made to the tabular crop location search page in the last two years (Figure 6). When administrative site hits from the State of Nebraska and University of Nebraska were subtracted, as well as non-Nebraska hits, a total of 676 web hits were recorded. It is assumed that most of these were by actual pesticide applicators, although many were likely people simply curious about the web site. (It is important to note that the spike near the left of Figure 6 coincides with the announcement of the Locater to pesticide applicators in NDA's Pesticide and Noxious Weed Newsletter.) This newsletter goes to many government partners, including USDA FSA/NRCS offices and Extension offices, some of which were noted in the list of Nebraska web hits during this time.

Figure 6. A chart of web site hits for the tabular crop location search page for the period October 1, 2009, through September 30, 2011 (20 visits is the upper bound of the y axis). This chart shows all web hits and has not been filtered for administrative hits from State of Nebraska or University of Nebraska sources.

In addition to web activity, UNL PSEP agreed to survey pesticide applicators to allow comparisons of their answers to the following measures:

Benchmark 3a	Goal 3a, 3b, & 3c	Measure 3a, 3b, & 3c (End of Year 2)
Subjective evidence that there is an interest on the part of applicators, based on requests for such information over the last several years, from both applicators and growers.	Approximately 80% of applicators surveyed will have heard about the Locater; 60% of those surveyed will have accessed the web site; and of those stating sensitive crops are nearby, 60% will indicate taking extra precautions.	Approximately 74% of applicators (including private and commercial) had heard of the Locater web site prior to attending the training session where the survey was conducted. Approximately 21% of applicators had actually accessed the web site. Approximately 61% of the people accessing the web site stated sensitive crops were nearby, and 100% indicated that they took precautions to avoid drift.

University of Nebraska Pesticide Safety Education Program personnel provided a survey to pesticide applicators attending pesticide applicator training sessions at select locations in 2011. Three questions concerning the Pesticide Sensitive Crop Locater were included in the survey, which contained approximately 20 other questions dealing with pesticide information presented at these sessions. Approximately 892 private applicators responded to the survey, and 344 commercial applicators answered the same three questions concerning their knowledge of the Locater, for a total of 1,236 responders. The questions are as follows:

A. Have you accessed the site to see if sensitive crops were near one of your application sites? (circle one)

Yes No Learned about the site today

If you answered "Yes" please proceed to ***A.*** *(if "No," please skip to comments)*

B. Were sensitive crops adjacent to one of your application sites? (circle one)

Yes No

If you answered "Yes" please proceed to **B.** *(if "No," please skip to comments)*

C. Did you take extra steps to avoid drift at this application site? (circle one)

Yes No

The measures for outcomes 3a, 3b, and 3c provided above are a combination of the results from both private and commercial applicators, which are shown, separately, below:

Private Applicators

Sensitive Crop Locater Web Site:	**Yes**		**No**		**Learned about the site today**		**Total**
	#	**%**	**#**	**%**	**#**	**%**	**#**
A. Have you accessed the site to see if sensitive crops were near one of your application sites?	154	17%	467	52%	271	31%	892
B. If you answered yes to A, were sensitive crops adjacent to one of your application sites?	63	28%	160	72%			223
C. If you answered yes to B, did you take extra steps to avoid drift at	117	76%	37	24%			154

this application site?							

Commercial Applicators

Sensitive Crop Locater Web Site:	Yes		No		Learned about the site today		Total
	#	%	#	%	#	%	#
A. Have you accessed the site to see if sensitive crops were near one of your application sites?	108	31%	189	47%	47	14%	344
B. If you answered yes to A, were sensitive crops adjacent to one of your application sites?	98	71%	40	29%			138
C. If you answered yes to B, did you take extra steps to avoid drift at this application site?	101	89%	12	11%			113

For Measure 3a, it is assumed that anyone marking “yes” or “no” to Question A, had prior knowledge of the Locater project and web site. However, this may not be a safe assumption given the unknowns about how word was spread once the initial announcement was made of its availability. Also, because the question did not specifically ask them if they had heard about the project, some responders may have answered “no” before considering the third potential answer to the question. In 2012, an additional question will specifically ask of their knowledge about the Locater prior to attending the training session, in addition to the three questions shown above.

Expected Measureable Outcome #4: A complete and spatially-accurate dataset will be created that will be used by researchers and commodity organizations as the stepping stone to agronomic research.

Benchmark 4	Goal 4	Measure 4 (End of Year 2)
Currently, agronomic research of the favorable site conditions needed for specialty crops is done on small scales because no statewide database exists.	At least one study will be conducted/published using data from the Locater as the basis for spatially evaluating agronomic conditions for specialty or other pesticide sensitive crops.	Ting Chen. 2011 Master’s Thesis: *Using a Geographic Information System to Define Regions of Grape-Cultivar Suitability in Nebraska*. This paper can be found at http://bit.ly/qqXzq8.

Beneficiaries

A listing of NDA's partners, targeted grower groups, newsletters, web sites, and other outlets for promoting the Pesticide Sensitive Crop Locater is provided in Appendices A and B. NDA's Ag Promotion and Development Division has been the primary avenue for distributing brochures and business cards. NDA personnel attend many grower events where one-on-one contacts were made. Business cards and the project brochure, *Protecting Nebraska's Pesticide Sensitive Crops*, are made available at these events and to project partners.

Lessons Learned

Although the number of database records have doubled since the web site was first publically announced, it is somewhat surprising that Goals 1 and 2 have not been achieved. Reasons for the slow start and lethargic numbers are unknown. A majority of the targeted producers have been informed via NDA's direct mailings to increase their awareness of the system and its potential benefits. These mailings were conducted during the winter months when farm planning and spring preparations traditionally take place. NDA assumes there may have been a large percentage of growers taking vacations, and it may simply take more than one exposure to reach the target audience if they clearly understand the system's benefits.

It is difficult to separate applicator web site activity from grower activity, but it is assumed that at least some applicators have looked at the data to satisfy their curiosity. Low activity by applicators may be due to some of the same reasons listed by growers, but it is likely due to the fact that the program is not widely known.

NDA will continue to send reminders via e-mail to grower groups and individuals, and will solicit help from UNL Extension Specialists and county Extension Educators. However, because of budget constraints, direct mailing of Locater information may not be done, unless it can be partnered with another NDA program.

Many of the specialty crop grower groups are not as organized as some of the more traditional commodity groups. In all cases, repeated exposure is needed for the program benefits to become apparent. NDA will continue to provide Locater business cards and brochures at every opportunity, as long as funding and human resources allow.

Information about the Locater is reaching pesticide applicators through Extension training sessions and NDA's newsletter. However, this outreach will need to continue, as a reminder to current and incoming applicators and as new information becomes available. NDA has explored other options as to how the

information is presented and stored. Currently, the server for the tabular and mapped data is at the University of Nebraska, and personnel are needed to maintain the data. The current model of having a grant funded position at the University is unsustainable. NDA is currently corresponding with the developers of Driftwatch to incorporate Nebraska's sensitive crop data into this multi-regional web site for sensitive crops. This web site has more functionality for applicators (e-notification when data is added) and will reduce the need for having a GIS/database specialist on staff. In addition, because the grower is able to outline their property boundary on-line, there is no need to request legal descriptions or Global Positioning Satellite (GPS) coordinates from them. Their property boundary becomes geo-referenced immediately. This should reduce the amount of time needed to double check crop location data. NDA is hopeful this new system will be in place by January 2012.

Contact Person

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Additional Information

Please refer to Appendices A and B for a listing of organizations and agencies that have received announcements, reports, and updates of the project, as well as a list of publications, web sites, and newsletters that have featured articles about the Locater project.

Appendix A. Project partners receiving initial announcements and subsequent updates on the Nebraska Pesticide Sensitive Crop Locater.

Grower Groups:

- Nebraska Winery and Grape Growers Association
- Nebraska Beekeepers Association
- Mid-America Fruit Growers Association
- Organic Crop Improvement Association
- Nebraska Chapter, Buy Fresh Buy Local
- Nebraska Nursery and Landscape Association
- Nebraska Sustainable Agriculture Society
- Nebraska Fruit and Vegetable Growers Association
- University of Nebraska Acreage E-News newsletter
- University of Nebraska Extension Specialists with agronomic expertise with these crops

Pesticide and Agricultural Industry Groups:

- Nebraska Aviation Trades Association
- Nebraska Agribusiness Association
- Nebraska Corn Growers Association
- Nebraska Sorghum Growers Association
- Nebraska Wheat Growers Association
- UNL CropWatch (an agricultural agronomy/Integrated Pest Management newsletter)

Local, State, and Federal Agencies:

- NDA's Ag Promotion and Development Division
- Nebraska Natural Resources Districts
- USDA Natural Resources Conservation Service
- USDA Farm Service Agency
- USDA Resource Conservation and Development
- UNL Extension Offices
- UNL Pesticide Safety Education Office

Appendix B. List of meetings, presentations, publications, newsletters, web site, and direct mailing promotions for the Pesticide Sensitive Crop Locater.

List of meetings attended or presentations given:

- AKSARBEN (September 2011) (NDA table with Locater information available)
- Husker Harvest Days (September 2011) (two NDA tables at separate locations with Locater information available)
- Nebraska State Fair (August 2011) (NDA table with Locater information available)
- Nebraska Academy of Sciences – April 2011
- Lincoln/Lancaster County Farmer Market Vendor Training – March 2011 (NDA presentation) (100 grower participants)
- Governor's Ag Conference (March 2011) (NDA table with Locater information available)
- UNL Extension Crop Production Clinics (applicator license recertification) – January 2011 (1,600 applicator participants)
- Nebraska Ag Classic (NDA table with Locater information available)
- Governor's Agri/Eco-Tourism Workshop (February 2011) (NDA table with Locater information available)
- UNL Private Applicator Training sessions – February to March 2011(10,560 applicator participants)
- UNL Commercial Applicator Training sessions – January to March 2011(1,295 applicator participants)

- Great Plains Vegetable Growers Conference, St. Joseph, Missouri, (four-state region table display, and NDA representation at Nebraska Roundtable) – January 2011 (25 grower participants)
- Nebraska Power Farming Show (December 2010) (NDA table with Locater information available)
- North Central Pesticide Education Workshop, Nebraska City, Nebraska, (NDA presentation and four-state region table display) August 2010 (35 partner participants)
- Nebraska NRCS State Technical Committee Meeting (handouts) September 2010 (20 partner participants)
- Nebraska Winery and Grape Grower Association convention, Kearney, Nebraska, (NDA presentation) – March 2010 (35 grower participants)
- Nebraska Aviation Trades Association Conference, Kearney, Nebraska, (NDA presentation) – February 2010 (100 applicator participants)
- Nebraska Sustainable Ag Society Conference, Lincoln, Nebraska, (business card/brochure handouts) – February 2010 (70 grower participants)
- Great Plains Vegetable Growers Conference, St. Joseph, Missouri, (four-state region table display, and NDA representation at Nebraska Roundtable) – January 2010 (25 grower participants)
- Mid-America Fruit Growers Association, Nebraska City, Nebraska, – January 2010 (R7 states table display) (50 grower participants)
- Nebraska Beekeepers Association, Gretna, Nebraska, (NDA presentation) – December 2009 (15 grower participants)

Major publications:

- Crops and Soil Magazine – September/October 2010
- Nebraska Farmer – February 2010

Newsletters:

- 2011 *Midwest Small Fruit and Grape Spray Guide*
- Nebraska Nursery and Landscape Association (Fall 2011)
- NDA Pesticide and Noxious Weed Newsletter (winter and summer 2011)
- Nebraska Aviation Trades Association (July 2011)
- Ag Air Update – June 2011 (also at http://issuu.com/aau_proofs/docs/06june2011)
- IPMnet NEWS; Oregon State University (Issue #181; September 2010)
- Lancaster County Extension NebLine (page 3 of March 2010 Weed Awareness insert)
- NDA Pesticide & Noxious Weed Newsletter (winter and summer 2010)
- Nebraska Aviation Trades Association (November 2009; January and July 2010)

- Nebraska Beekeepers Association (November and December 2009; January and July 2010)
- Nebraska Organic Crop Improvement Association (Winter 2010)
- UNL Viticulture (December/January 2010 and March/April 2010)
- Northeast Nebraska RC&D (April and July 2010)
- Nebraska Aviation Trades Association (July 2010)
- Nebraska Sustainable Agriculture Society (May/June 2010)
- PIREPS (Nebraska Department Aeronautics) brief summary of NATA convention, including NDA presentation (April/May 2010)
- UNL CropWatch (January 15, 2010)
- UNL Acreage E-News (April 2010)
- UNL Organic (on Twitter) (November 12, 2009)

Web Sites:

- UNL Entomology – Extension Program links
- Nebraska Winery and Grape Growers Association (link to Locater brochure)
- Nebraska – Our Best To You (FY11)
- NDA Update radio report (not archived) May 2-8. Distributed via RSS Feed, to media outlets and made available on NDA's web site. The RSS link for this podcast had approximately 3,000 hits for May, 2011.
- NDA Facebook Page (May 2, 2011)
- NDA Twitter page (May 2, 2011)
- NDA Update – audio file distributed to Nebraska Media (May 2011)
- UNL IPM in Schools blog
- Midwest Producer (March 9, 2010)
- Nebraska Aviation Trades Association
- Ag Professional (January 20, 2010)
- UNL Water Portal
- UNL Pesticide Safety Education Program
- UNL West Central Research and Extension Center (December 2009)
- BBE-Tech Honey Bee Conservation Blog (December 2009)
- Nebraska Farmer (January 2010)
- USAgnet (January 19, 2010)

Note: Web links to the entries listed above are provided, if they currently contain information on the Pesticide Sensitive Crop Locater. Electronic files for many of these have been saved and are available upon request.

Direct Mailings:

- E-mail to USDA Organic, NDA Organic, and NDA Specialty Crop Growers; February 2011 (count = 520)

- NDA Organic Certification Cost-Share Program letter (included Pesticide Sensitive Crop Locater business card); August 2010; (count = 220)
- NDA Licensed Aerial Applicator letter (with brochures); January 2010 (count = 450)
- Initial announcement - NDA specialty crop and senior farmers market program mailing list; January 2010 (count = 540)
- Initial announcement - NDA Organic mailing list; January 2010 (count = 220)
- NDA letter to Nebraska RC&D offices (with brochures); November 2009 (count = 12 offices)

Project Title

Hybrid Hazelnuts: Propagation for Future Field Demonstrations in Nebraska

Project Summary

Hybrid hazelnuts have been researched as a potential crop for production in Nebraska and the results show great potential in regards to kernel yields and oil quality characteristics. Two hybrid hazelnut research orchards have been established in eastern Nebraska at Arbor Day Farms in Nebraska City, Nebraska, and more recently at Horning Farm near Plattsmouth, Nebraska. The University of Nebraska – Industrial Agricultural Products Center, Nebraska Forestry Service, Oregon State University, and Rutgers University have coordinated research efforts to identify the best hybrid hazelnut cultivars from these orchards for future propagation. This research, combined with current propagation practices, and nursery grow outs will require at least three years before the best commercial varieties will be available. The primary challenges to developing a hybrid hazelnut industry in Nebraska include educating agricultural producers, getting them to adopt an alternative cropping system, and adapting the seedlings to respective climatic conditions across Nebraska. For Nebraska to be a leader in the hybrid hazelnut industry, producer education and production demonstrations should begin years before the best cultivars are actually available.

Specific research objectives were to 1) select cultivars that have characteristics suitable for production in Nebraska, 2) identify suitable propagation techniques for the select cultivars, 3) propagate the select cultivars and evaluate their survival rates, and 4) continue monitoring survival and growth rates of the select cultivars in a nursery to prepare for future field plot demonstrations that can further evaluate field plot survival and growth rates.

The purpose of this research project is to evaluate the success of hybrid hazelnut propagation techniques suitable for large scale multiplication of hybrid hazelnut cultivars and to prepare for future evaluations of the adaptability and durability of propagated hazelnut seedlings in commercial field production systems.

Project Approach and Goals and Outcomes Achieved

The research project has progressed well, but propagation proved extremely difficult. The few explants that were established from forced buds as reported in the interim report (May 2010) were infected with fungi and molds soon after. Explants that were not initially infected were cleaned and transferred to new sterile containers, but were similarly infected in the following weeks. Propagation efforts continued throughout the summer of 2010 but only one plant has been successfully propagated and that was by the more traditional in-field mounded root layering method. The research objectives were completed as outlined below and future propagation efforts will continue under a subsequently funded

Specialty Crop Block Grant that followed this research project and is funded through September 2012.

Progress related to research objective #1: select cultivars that have characteristics suitable for production in Nebraska

H. hazelnut cultivars, grown at research sites in Nebraska by the Nebraska Forest Service, were reviewed to identify the cultivars that currently appear to have the greatest potential for future commercial application. The primary characteristics of concern were resistance to Eastern Filbert Blight (EFB) and harvestable nut production. With this in mind, 12 cultivars were selected and cuttings were collected in March 2010 for tissue culture research that began in April 2010. That was a larger sample than identified in the proposal, but cuttings from 8 of the 12 cultivars were from NADF plants that were open pollinated. Therefore, each of those 8 plants actually represented unique cultivars that are anticipated to have similar characteristics.

The Grand Travers (GT) cultivar is the hybrid that typically produces the largest nuts, the largest overall annual crop per plant, and shows no signs of EFB infection. The Skinner cultivar also shows no signs of EFB infection and typically produces more nuts per plant, but the nuts are smaller than the GT, thus producing a lower overall yield. NADF plants are known to be good yielding plants that tend to have similar characteristics and have shown no signs of EFB infection.

Two other cultivars, G502 and 88BS also were selected for experimentation on a limited basis. These cultivars have shown some susceptibility to EFB and, therefore, are not considered to have as much commercial potential, but will provide exposure to the broader germ plasm.

Progress related to research objective 2: identify suitable propagation techniques for the select cultivars

Propagation methods for h. hazelnut were further reviewed and four methods were initially selected for evaluation. The methods were tissue culture from h. hazelnut buds, tissue culture from h. hazelnut leaves, chip bud grafting, and mounded root layering in the field. H. hazelnut cuttings were also collected from the field in June for root layering in the laboratory environment. The chip bud grafting experiments were conducted by the Nebraska Forest Service (NFS) staff in 2010 as a continuation of past research. NFS research was monitored and reported as part of this project. Mounded root layering is an in-field propagation method that involves cutting back previous growth and working with new shoots that grow from the root ball. Six plants were selected and cut back in April 2010 and the new shoots from three plants were lightly girdled, treated with rooting hormone, and mounded with media in June 2010. The 3 remaining plants

provided vegetative tissue for future tissue culture propagation efforts in 2011 and beyond.

Tissue culture propagation from h. hazelnut buds has been reported in the literature, but involves labor intensive technical expertise with limited results. Tissue culture propagation from h. hazelnut leaves is not known to have been tried in the past, but it may provide alternative plant material for tissue culture propagation. Chip bud grafting has been conducted by NFS staff in the past but with unsatisfactory results. Mounded root layering is common for many woody shrubs but requires destruction of most of the above ground plant growth and is anticipated to only produce a dozen or so shoots per plant each year.

An additional tissue culture propagation technique, embryogenesis was evaluated in 2011. This technique is designed to limit the unsterile material that infected the tissue cultured buds collected from the dormant cuttings. Embryo axis germination uses the embryo axis immediately before it emerges from the h. hazelnut seed. The h. hazelnut seeds were selected from 2010 seed production of undetermined crosses. If the process is successful, future propagation will use seeds produced from known crosses that will be available from Oregon State University, Rutgers University or other h. hazelnut plant breeders. This will not lead to clones of the specific cross as each cross can be unique, but it will provide h. hazelnut plant material with the least susceptibility to infection.

Progress related to research objective 3; propagate the select cultivars and evaluate their survival rates

240 dormant h. hazelnut cuttings were collected in March 2010 before the buds were growing actively and placed in cold storage. In April 2010 the cuttings were cleaned and placed in forcing solution to prepare for tissue culture propagation from the buds and leaves. The plant material was growing in the lab in May 2010 from forced buds, but unfortunately by June 2010 the explants were infected with fungi and molds. Explants that were not initially infected were cleaned and transferred to new sterile containers, but were similarly infected in the following weeks. Efforts to propagate explants from tissue culture buds continued throughout the summer 2010 but with no survival beyond 5 weeks.

Tissue cultured callous material from prepared leaves was visible in May 2010, which was a positive sign for future plant development. Callous material was removed from the leaves in July 2010 and continued to slowly grow in the laboratory for several months. Efforts to initiate plant growth from the callous material were not successful. This approach is typically used for non-woody plants, but considering the challenges associated with using tissue from the dormant buds, this method provided an alternative tissue source to evaluate.

H. hazelnut cuttings collected from the field in June 2010 for root layering in the laboratory environment were not successful as the cuttings became infected with

fungi within 1 week. Chip bud grafting was attempted by the Nebraska Forest Service staff in 2010, but without success.

The in-field mounded root layering has provided the only successful propagation method and that resulted in only one plant. This result was equally disappointing as this traditional method was expected to produce approximately 12 plantlets for each of the three plants mounded. Unfortunately, rodent infestation in the h. hazelnut orchard was extremely high and voles tunneled into the mounds and feed on much of the new vegetative growth. In one case all vegetative growth was killed off. In the other mounds, the vole damage completely severed some of the growing shoots. One shoot established a very limited root structure and was transplanted into a 1 gallon pot and transferred to the greenhouse in preparation for winter dormancy.

Propagation of h. hazelnut embryo axis germination was evaluated in 2011. The technique was designed to limit unsterile material that could contaminate the tissue culture plant material or media. Embryo axis germination uses cold stratified embryo axes immediately before they emerge from the h. hazelnut seeds. The h. hazelnut seeds were selected from 2010 seed production of undetermined crosses. 40 kernels from two trees were evaluated for seed quality and 22 axes were selected for germination on growth media, of which 7 immediately became contaminated with fungus. Initially 12 of the 15 remaining axes appeared to survive, but within 3 weeks only 9 showed signs of growth. These 9 plants grew slightly over the following months but eventually 4 became contaminated with fungal growth. As of September 30, 2011, 5 plants are alive but 3 have very low plant vigor.

Considering the repetitive contamination associated with the multiple micro propagation efforts of h. hazelnut plant materials, non-hybrid hazelnut plant material was obtained to evaluate propagation techniques and methods. Non-hybrid hazelnut plant material, *C. avellana,* was provided by the National Colonal Germplasm Repository of Corvallis, OR (Repository). The cultivars were: Jefferson, Yamhill, Santium, Epsilon, Theta and Gamma. Propagation of the *C. avellana* material was successful with various growth rates for the 6 specific cultivars evaluated. Jefferson and Yamhill cultivars initially showed more vigor than other cultivars. The Theta cultivar has acclimated to the laboratory environment as well and each of these 3 cultivars have been readily propagated, transferred to fresh media, rooted and transferred to soil. The Epsilon and Santium cultivars are acclimating to the laboratory environment as well but with less vigor. The Gamma cultivar has very low vigor. As of September 30, 2011, 160 *C. avellana* plants are growing in the greenhouse and are being prepared for cold storage. In May 2012, these *C. avellana* plants will be planted in experimental plots to evaluate their growth in multiple locations in Nebraska along with h. hazelnut plants produced from seed. Successful propagation of these non-hybrid cultivars provides a comparison of the propagation techniques with both hybrid and non-hybrid varieties. Only limited numbers of the non-hybrid

varieties became contaminated during transfer, while all efforts to micro propagate h. hazelnut have consistently resulted in fungal contamination.

Progress related to research objective 4: continue monitoring survival and growth rates of the select cultivars in a nursery to prepare for future field plot demonstrations that can further evaluate field plot survival and growth rates

Adaptation of plants to the nursery environment depends on propagation success and plant growth rates. With the limited propagation success, only one plant from the mounded root layering established a limited root system. This plant was transplanted into potting soil and transferred to a NFS nursery on October 18, 2010 to continue root development before entering winter dormancy. This plant survived winter dormancy and continued to grow in the nursery environment throughout 2011 at rates similar to other h. hazelnut plants established from seed. It will be transferred to cold storage for the winter and will be planted in May of 2012 along with the *C. avellana* plants. These plants will continue to be monitored in the in-field demonstration plot environment.

IAPC initiated h. hazelnut propagation efforts in 2010 that confirmed the difficulty in propagating h. hazelnuts. Efforts were made to propagate h. hazelnuts via in-field mound layering, and micro propagation of dormant bud tissue with very little success. Specifically the dormant bud tissue could not be sufficiently cleaned to support successful micro propagation efforts. The in-field mound layering showed some potential with the production of one rooted shoot, but improved mound layering techniques and pest management needs to be implemented for a better evaluation and development of a successful propagation program.

Propagation efforts in 2011 focused on embryo axis propagation of h. hazelnut and propagation of *C. avellana* hazelnut cultivars available from the National Colonal Germplasm Repository of Corvallis, OR (Repository). The embryo axis propagation efforts looked promising initially with 12 of 15 propagations surviving on tissue culture media. Unfortunately after 3 weeks only 9 propagations were showing signs of growth. These 9 propagations grew slightly over the following months but 4 more have become contaminated with fungal growth. As of September 30, 2011, 5 plants are alive but 3 of those have very low plant vigor. Propagation of the *C. avellana* material from the Repository has been successful for 3 cultivars with various growth rates. Successful propagation of this non-hybrid cultivar provides a comparison of propagation techniques with both hybrid and non-hybrid varieties. Only limited numbers of the non-hybrid varieties became contaminated during transfer, while all efforts to propagate h. hazelnut have been unsuccessful.

As of September 30, 2011, only one h. hazelnut plant has successfully been propagated via mound layering and grown to a size suitable for nursery conditions. Micro propagation of dormant buds and leaf material was

unsuccessful as were root layering and chip bud grafting. The one plant from mound layering represents traditional in field propagation. This plant will over winter in cold storage and be planted in May 2012 along with the 160 plants propagated from the *C. avellana* cultivars.

Beneficiaries

The research performed will benefit the hazelnut industry with further documentation of the challenges associated with propagating h. hazelnuts. More specifically, project staff has gained a broader perspective of the challenges associated with large scale propagation efforts for h. hazelnuts. This will indirectly benefit Nebraska specialty nut crop producers, food processors, nut traders as they understand the challenges associated with large scale commercial production of hazelnut in Nebraska.

Troy Pabst of the Nebraska Forest Service provided an update of efforts to commercialize h. hazelnut in Nebraska at the Upper Midwest Hazelnut Growers Conference. His presentation primarily focused on the Nebraska Forest Service's efforts, but also included the Industrial Agricultural Products Center's research efforts to identify propagation techniques suitable for large scale commercial development. This Conference reached approximately 60 nut producers from the Iowa, Minnesota, Nebraska, and Wisconsin area and was held in West Saint Paul, MN on March 4 and 5, 2011.

Lessons Learned

The research team was disappointed that current research efforts have not resulted in successful propagation techniques for Hybrid hazelnut (h. hazelnuts) thus far, but the research has been very beneficial in providing additional knowledge to support the identification of large scale reproduction methods for hybrid hazelnut cultivars in the future. This research is an important key to identifying alternative propagation techniques and addressing the overall goal of developing and commercializing hybrid hazelnut production as an alternative oilseed crop for Nebraska.

The repetitive fungal contamination of multiple h. hazelnut micro propagation efforts and the lack of contamination in *C. avellana* provide some evidence that a fungal endophyte may exist in the tissue of h. hazelnut that makes it susceptible to contamination in the micro propagation environment. An initial screening of resulting fungi were plated and identified as *Penicillium*, *Alternaria*, and *Cladosporium* along with unidentified bacterium. It is recommended that future research specifically evaluate the potential existence of a fungal endophyte and alternative propagation strategies such as incorporating alternative fungicides into the growth media for h. hazelnut micro propagation.

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Additional Information

Collaborative efforts continue to develop between the University of Nebraska – Industrial Agricultural Product Center and the Hybrid Hazelnut Consortium, specifically the Nebraska Forest Service, and the National Arbor Day Foundation. The research team conducting propagation efforts for this project participated in the 2010 Hybrid Hazelnut Consortium visit to Corvallis, OR to visit Oregon State University research orchards and facilities, three commercial hazelnut orchards, two nurseries specializing in hazelnut propagation, the National Clonal Germplasm Repository, and a hazelnut processing facility that supplies confectionary grade hazelnuts. This visit expanded our research teams understanding of the industry, but more specifically it allowed us to evaluate propagation techniques currently utilized for the European hazelnut species (*C. avellana*), which may be adaptable to h. hazelnut.

Associated publications related to the potential for h. hazelnut production in Nebraska:

1. Yixiang Xu, Edward Sismour, John Parry, Milford Hanna, Haiwen Li (2011) Chemical composition and antioxidant activity in hazelnut shells from US-grown cultivars. *International Journal of Food Science and Technology*, under reviewed.
2. Yixiang Xu, Andreia Bianchini, Milford A. Hanna. (2011). Evaluation of Mold and Mycotoxin Contaminations in Hybrid Hazelnuts Grown in Nebraska. *Journal of Food Processing and Technology*, 2, 5.
3. Yixiang Xu, Milford A. Hanna (2011) Nutritional and anti-nutritional compositions of defatted Nebraska hybrid hazelnut meal. *International Journal of Food Science and Technology*, 46, 2022-2029.
4. Yixiang Xu, Milford A. Hanna (2010) Nutritional quality and oxidative stability of oil extracted from hybrid hazelnuts. *International Journal of Food Science and Technology*, 45 (11), 2329-2336.
5. Yixiang Xu, Milford A. Hanna (2010) Evaluation of Nebraska hybrid hazelnuts: nut and kernel characteristics, proximate, oil and protein compositions. *Industrial Crops and Products*, 31 (1), 84-91.
6. Yixiang Xu, Milford A. Hanna (2009) Synthesis and characterization of hazelnut oil-based biodiesel. *Industrial Crops and Products*, 29 (2-3), 473-479.
7. Yixiang Xu, Milford A Hanna, Scott J Josiah (2007) Hybrid hazelnut oil characteristics and its potential oleochemcial application. *Industrial Crops and Products*, 26, 69-76.

Project Title

New Hosts for the Dry Bean Bacterial Wilt Pathogen in Western Nebraska

Project Summary

Bacterial wilt of dry beans, caused by *Curtobacterium flaccumfaciens* pv. *flaccumfaciens* (*Cff*) was a sporadic but often serious production problem in dry beans throughout the irrigated High Plains since first being reported from South Dakota in 1922. It was first observed in western Nebraska dry bean production fields in the early-mid 1950s, and continued to be economically important throughout the 1960s and early 1970s. The disease then only periodically appeared in seed, but has had little detectable effect on yields after the implementation of crop rotation and seed sanitation practices. The disease has now re-emerged and has been documented from more than 400 fields since 2004. It is not known why the disease has suddenly appeared again in dry bean production areas over the last four years to this extent, but it does warrant some concern.

Over this same time period, beginning about 2006, soybean plants were identified in western Nebraska fields that were harboring bacterial isolates with the ability to cause disease on dry beans after artificial inoculations. Thus. it was important to be able to document the distribution and incidence of the pathogen naturally occurring in production fields consisting of alternate crops grown in rotation with dry beans. Therefore, UNL began a study in 2008 to survey fields in western Nebraska to address this concept. This report presents data collected from a new study that represents a continuation of this concept which was conducted during the 2009-2010 seasons.

Project Approach and Goals and Outcomes Achieved

Between early July and mid-September from 2009-2010, production fields were scouted for symptoms consistent with bacterial infections. The survey consisted of 336 fields, representing 11 counties in western Nebraska – Scotts Bluff, Morrill, Box Butte, Sheridan, Sioux, Banner, Kimball, Cheyenne, Keith, Perkins, and Deuel.

From these fields, 645 symptomatic samples were collected and processed for identification of potential bacterial infections. Total number of samples from each crop or plant type included: alfalfa (6), brome grass (1), camelina (5), chickpeas (1), chicory (5), corn (113), dry beans (258), eggplant (2), millet – proso and foxtail (11), grapes (2), oats (2), pumpkins and gourds (4), soybeans (13), sugar beets (26), sunflowers (119), triticale (2), wheat (54), and assorted other weed species (21).

All samples were either cultured on standard growth media (NBY – nutrient broth yeast agar) or were incubated in a humidity chamber. As bacterial growth emerged from symptomatic tissues, they were re-streaked on new media and observed for colony growth characteristics and color. All recovered isolates were then tested by the Gram stain technique, which identifies the bacteria as either Gram positive or Gram negative. All Gram positive isolates were labeled and saved for later tests, as *Cff* is Gram positive.

For both seasons combined (2009-2010), 143 Gram positive samples were identified, 73 of which were from dry beans. This means another 70 were found in association with other crop and weed species, which represented more than 18% of the total number of non-dry bean samples collected. UNL tested isolates for pathogenicity on dry beans. This procedure was extremely time-consuming and was limited by a lighted growth chamber space. However, one of the highlights was finding another dry bean pathogenic isolate from sunflower, which represented another new crop from which UNL obtained *Cff* isolates.

Researchers were continually surprised by the high number of isolates recovered from the alternative crops during the course of this study in 2009-2010. Isolates have been obtained from five distinct alternative crops that are commonly grown in rotation with dry beans in Nebraska, including soybeans, wheat, corn, alfalfa, and now sunflowers.

Higher numbers of isolates were found during 2009, than in 2010, but it is uncertain as to why. Nevertheless one of the most important results obtained was developing better methods for screening the large numbers of samples that were obtained over the course of the study. It was discovered that putting the symptomatic tissue in humidity chambers for 24-36 hours, resulted in high yields of numerous bacterial residents in tissues, which are more easily separated on media rather than plating surface-sterilized tissues directly on media and waiting for growth to emerge from tissue pieces. The bacteria from plated material then still had to be re-streaked on additional media to properly purify and separate colonies for further identification. This new method saved one step in the procedure making our efforts more efficient and cost effective.

It was additionally discovered that it is not necessary to screen corn isolates against the Goss' wilt-selective medium (CNS). Goss' wilt pathogen was ruled out and separated from the wilt pathogen by using a general all-purpose medium (NBY) and observing color and colony morphology differences. Additionally, in many instances, those fluorescent Pseudomonads affecting beans and other crops like corn and sunflower can rapidly be eliminated from the evaluations by simply applying a hand-held black light apparatus over the pods, leaves, or cultures and observing the fluorescent pigments being produced by those organisms. Those isolates producing fluorescence are automatically eliminated as candidates for wilt before attempting the Gram test, thus saving more time with rapid diagnoses. Over the course of this study, UNL has identified at least

26 isolates associated with other crops grown in rotation with dry beans that are additionally capable of causing the wilt disease in dry beans (7% of the total number of isolates collected from non-dry bean crops). Others may be found later as we continue to test previously collected isolates currently in storage. These data suggest that the pathogen is widely distributed throughout western Nebraska production fields.

Additionally, pathogenic isolates from all market classes of dry beans, including Great Northern, pinto, black, yellow, small red, kidney, navy, pink, and Anazazi were tested and identified. Furthermore, UNL additionally found all three of the previously identified pathogen color variants (orange, yellow, and purple), while also discovering a fourth variant never before reported (pink). This continues to illustrate the great degree of diversity within this pathogen, and may also allude to its adaptive ability to survive in association with non-host crops.

It is not known how this pathogen may affect corn, wheat, soybean, alfalfa, sunflower, or potentially others as yet undetected, but at the very least, these additional crops may serve as alternate hosts for the pathogen by serving as a survival mechanism and providing a source of inoculum for infecting dry beans when they are put back into the rotation. (This issue is currently being addressed in another NDA-funded study).

Beneficiaries

Because it is uncertain as to how this pathogen may affect corn, wheat, soybean, alfalfa, sunflower, or potentially others as yet undetected, it is projected that these additional crops may serve as alternate hosts for the pathogen by serving as a survival mechanism and providing a source of inoculum for infecting dry beans when they are put back into the rotation. Finding widespread evidence of pathogenic bacterial wilt isolates associated with crops other than dry beans would substantially change the beliefs on how this disease was previously assumed to function. Rectifying this potential problem, would require new practices for management, which are currently not being implemented. Therefore, a significant level of education is warranted to convince producers of the potential dangers of this pathogen.

The beneficiaries of this project include seed companies, producers, crop consultants, and field scouts. New scientific findings would require practical methods for management to be developed. This disease affects the producer's profits by reducing both yield and quality parameters. This, in turn, affects the processor and the general economy of the communities where dry beans are produced. Because of quarantine restrictions placed on bean seeds grown in infested fields, the dry bean breeding program at UNL would be adversely influenced due to the inability to exchange or ship seeds to some countries for scientific or food consumption purposes. This would then affect the economy of

the state of Nebraska and its ability to produce new dry bean cultivars or commercially sell dry beans to other countries.

It is estimated that 1,500 to 1,600 individuals have been affected by the implementation of this project, most of whom are Nebraska growers.

This project has changed the industry's paradigms on how this disease was once thought to behave. For years, it has been know that bacterial pathogens survive in residue, but this occurred primarily in residue from which the pathogen infected and caused the disease. However, the results of the project suggest that the wilt pathogen also survives in other crop residues grown in rotation with beans, potentially allowing survival until beans are put back into crop rotation.

Another important aspect to this disease was simply learning of its biology and/or pathology. More than two dozen isolates from corn, soybean, wheat, alfalfa, and sunflower that cause wilt on dry bean plants have been collected. Additionally, methodologies were developed for quickly isolating and distinguishing these strains from others found as members of bacterial disease complexes on these crops. This knowledge is now being put to use with a project UNL is now conducting with the American Seed Trade Association to develop and compare methodologies for detecting wilt from seed with the purpose of easing fears for our US-grown seed being sent to Kenya (and potentially other countries).

Results obtained as a result of this project have been disseminated in several different venues and functions including those involving peers, students, growers, consultants, and laymen. This information has been presented to Nebraska dry bean growers at the Nebraska Dry Bean Commission meetings and the Stateline Grower Cooperative meetings. It was also presented to growers and consultants at UNL Extension's Crop Production Clinics in Scottsbluff, Gering and Ogallala, and to those who attended the National American Phytopathology (APS) and Bean Improvement Cooperative (BIC) meetings. Both of the latter two meetings included regional, national, and international audiences.

A presentation was recorded for a UNL Extension webinar that was available for viewing by all Extension Educators in the UNL system. It was presented, recorded, and viewed live for all states and interested scientists throughout the Great Plains Diagnostic Network (GDPN). This encompassed the states of Nebraska, South and North Dakota, Montana, Colorado, Wyoming, Kansas, Oklahoma, and Texas. Portions of this data were presented to the Nebraska LEAD group the last 4 years. It was also presented to the PHREC and Plant Pathology Department seminar series, Rocky Mountain Agri-business Association, Servi-Tech annual meetings, and the Colorado/Nebraska Crop Clinics.

From the venues identified above, it is estimated that 1,500 to 1,600 individuals have been directly exposed to this study. Another potential 5,000 to 6,000

viewings could have been made from recorded webinars and international pathology/dry bean meetings.

Lessons Learned

The only problems experienced was wading through isolates and then evaluating pathogenicty in the growth chambers. The tests last approximately one month, and there is space for only 5-6 isolates (with 4 replications per isolate) at a time.

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Additional Information

UNL would like to continue to test various isolates for pathogenicity on beans, particularly from some of the more obscure crops or plants. Eventually, it would be helpful to document this phenomenon from as many counties, fields, and plant species as possible. Wilt was much more severe in 2009 than in the previous 2 years, but 2010 was not as severe as 2009. UNL is keeping track of severely affected fields from all years and will periodically re-visit fields to look for the presence of these isolates and the time periods since the crops harboring wilt isolates were found, compared to when dry beans were in the rotation.

Table 1. Gram + Bacterial Isolates Collected from Alternative Crops in Nebraska and Determined to be Pathogenic on Dry Beans.

Crop	Number of Isolates
Alfalfa	3
Corn	10
Soybean	8
Wheat	4
Sunflower	1
Total	26

Project Title

Encouraging the Use of Nebraska Dry Beans in the Chinese Diet

Project Summary

China is a large producer of dry edible beans, but their large population doesn't traditionally consume these beans in their diet. Therefore, in recent years, most of these beans have been exported to countries that have been served by the Nebraska/U.S. dry bean industry. This competition has decreased Nebraska/U.S. dry bean marketing options, leading to low/fluctuating prices and an unstable marketing environment that threatens the industry.

This project addressed the problem by encouraging the use of Nebraska dry edible beans in the Chinese diet. The basic Chinese diet consists of rice and noodles, and the protein content usually comes from pork or chicken. As the prices of meat have increased, the amount of pork and chicken consumed by a large share of the population has decreased because of the price of these protein sources. Key Chinese government officials are concerned about the lack of protein in the Chinese diet and see it as a problem.

Nebraska dry edible beans could serve as an affordable protein-rich replacement, provided Chinese citizens are made aware of this option and understand how to incorporate it into their diets.

The overall goal of this project was to solely enhance the competitiveness of Nebraska grown dry edible beans within the Chinese market, leading to improved marketing channels for Nebraska dry edible beans. This was accomplished by hosting a conference for key Chinese government officials and food manufacturers to demonstrate the incorporation of Nebraska dry beans into the Chinese diet. By increasing the use of Nebraska dry edible beans in the average Chinese diet, it will help make their diets healthier with increased protein and create new opportunity for exports of Nebraska dry edible beans.

Project Approach and Goals and Outcomes Achieved

Expected Measurable Outcome #1: Identify the number of Chinese manufacturers, Nebraska processors, and governmental officials interested in participating in this project. NDA worked with the Nebraska Dry Bean Commission (NDBC), the USDA Agricultural Trade Office (ATO), and the U.S. Embassy to identify Chinese manufacturers and processors and determine how many people would attend this conference. A total of 125 participants attended the conference, which consisted of approximately 55 manufacturers and food suppliers, 10 dry edible bean processors, and 60 academia and government officials representing China and the U.S.

Expected Measurable Outcome #2: Establish the team that will organize, host, and conduct the conference. A team was established to organize and conduct the Conference. The team consisted of NDA and U.S. Embassy staff, ATO employees, members of the Chinese Institute for Food Science and Technology and the Nebraska Dry Bean Commission. NDA worked with the USDA ATO in Beijing to find a hotel in Beijing, China to host the event and worked with the Commission and ATO to develop the conference agenda. The one-day event held in August 2011 featured three University of Nebraska – Lincoln (UNL) food science professors. The first discussed food manufacturing and the use of Nebraska dry beans in food products with the manufacturing companies. The second explained the nutritional benefits of dry beans and culinary perspectives to chefs and government officials, and the third discussed the features of Nebraska dry beans. The feedback from the conference attendees was outstanding. Following this conference, it was discovered that Chinese manufacturers and processors want to conduct one-on-one meetings to further investigate the incorporation of dry edible beans into Chinese formula and menu items.

Expected Measurable Outcome #3: Educate and encourage the use of Nebraska dry edible beans in the Chinese diet. The third goal of this project was to conduct a conference to educate the Chinese manufacturers and food suppliers as to how Nebraska dry edible beans can be incorporated into Chinese instant noodle cups and menu items. Both targets under this outcome was achieved. Five Chinese manufacturers and processors would like to investigate the possibility of incorporating dry edible beans into the instant noodle cup formula. In the spring of 2012, they will travel to Nebraska to test and develop methods that will allow for the inclusion of dry edible beans into their formulas and menu items.

Beneficiaries

Approximately 55 manufacturers and food suppliers, 10 dry edible bean processors, and 60 academia and government officials representing China and the U.S. benefitted from the implementation of this project. Addtionally, all U.S. dry edible bean growers will hopefully benefit from this project, especially those in Nebraska, Minnesota Michigan, and North Dakota, which are among the top dry bean producing states in the nation. It will create new opportunities for exports of Nebraska dry edible beans and hopefully increase the sales of all U.S. dry beans. Increasing the use of dry edible beans in the average Chinese diet will make their diets healthier by increasing their protein intake. Educating and encouraging the use of dry edible beans in the Chinese diet/market so that expanded marketing opportunities are opened for Nebraska and U.S. dry edible beans is the long-term goal for this project, which will have far reaching benefits that will extend beyond the length of this project.

Lessons Learned

This conference was an outstanding opportunity to share the results of dry bean research in real-work setting. It has great potential to have a positive impact on dry bean farmers in Nebraska and the U.S. It was the result of previous visits with Chinese government officials. Chinese have a strong desire to incorporate more protein into the diets of Chinese citizens and this event worked with them to understand that Nebraska dry edible beans can fill that void. The Nebraska delegation also spent a day at the Chinese Agricultural University's School of Science and Nutrition Engineering and visited the Wu Gu Dao Change Foods Company, Ltd. To discuss the technical aspects of incorporating Nebraska dry edible beans into Chinese food products.

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Additional Information

None

Project Title

Identification of Mycoflora species and Mycotoxin Contaminations in Nebraska Hybrid Hazelnuts and Strategies for Prevention

Project Summary

Hybrid hazelnuts are emerging as a promising oilseed crop in Nebraska that requires relatively low inputs and can be produced on marginal lands. These commercial-quality hybrid hazelnut shrub cultivars, which combine the superior qualities of the European hazelnut with disease resistance and cold hardiness of the American species, show great potential as an oilseed crop in the Upper Great Plains. The results of previous studies have shown Nebraska hybrid hazelnuts are a promising oilseed for food and value-added industrial applications.

However, vulnerability to being attacked by fungi, thereby, producing toxic secondary metabolites, such as aflatoxin, fumonisin, and zearalennone, is a big concern during nut storage, since these mycotoxin contaminations represent a significant food safety issue. They have serious adverse effects on human and animal health. Aflatoxin, especially aflatoxin B1, is a potent carcinogen and teratogen, while fumonisins cause many diseases and promotes cancer. The U.S. Food and Drug Administration set a maximum limit of 20 ng/g for total aflatoxin in human food. Further, the European Commission established much lower limits of 4 ng/g for total aflatoxin and 2 ng/g for alfatoxin B1. These limits restrict international trade. Hence, from food safety and international trade points of view, it is very important and timely to conduct research to determine mold and mycotoxin contaminations during harvest, processing and storage of Nebraska hybrid hazelnuts and to develop protective methods and strategies to minimize food safety and security concerns.

The specific objectives of this project are to identify and evaluate mycoflora species and mycotoxin contaminations in Nebraska hybrid hazelnuts. The project builds on a series of previously approved projects and supports our initiative to extend our research to address safety and security issues with respect to Nebraska hybrid hazelnuts.

Project Approach

1. Following are summaries of the experiments conducted to address the specific objectives.

    (a) Identification and isolation of different mycoflora species grown in Nebraska hybrid hazelnuts, de-shelled nuts, and ground meals, in terms of total mold counts and isolation and purification of mycoflora species. Hybrid hazelnuts were hand harvested from the Arbor Day Farm in Nebraska City, Nebraska. After harvest, some

nuts were shelled. Portions of the shelled nuts were ground. The nuts, kernel, and ground meal were sealed in double sterile polyethylene bags to minimize the loss of water. Total molds and mold species of the samples were determined using a dilution plate method. About 25 g hazelnut samples (nuts, kernels, and ground meals) were suspended in 225 ml of 0.1% peptone solution. Homogenized samples were diluted with 0.1% peptone solution to concentrations of 10^{-2}, 10^{-3}, 10^{-4}, and 10^{-5}. The dilution samples (about 100 µl) were transferred into sterile Petri dishes containing Dichloran Rose Bengal Chlortetracycline (DRBC) agar, and then were spread on whole plates. The dishes were incubated at 25 ºC for 5 days. After counting told amounts, the colonies of each mold species were isolated and sub-cultured on potato dextrose agar. The dishes were incubated at 25 ºC for two days, and then transferred onto another potato dextrose agar for 5 days prior to identification of the species. The spores were taken using looping and dissolved into 0.1% aqueous agar. The isolates were inoculated as three point inoculations in petri dishes containing a growth medium. Three media, Czapek yeast autolysate Extract Agar (CYA), Malt Extract Agar (MEA), and Creatine Agar (CREA), were used. After incubation for 7 days at 25ºC, fungal species were identified based on their macroscopic and microscopic characteristics by visual examination under a stereomicroscope.

(b) Qualitative assessment of the potential mycotoxins

The potential mycotoxins including aflatoxins B1, B2, G1, and G2, ochratoxin, produced mainly by species of *Aspergillus, Penicillium*, or *Fusarium*, were qualitatively assessed using multi-toxin thin-layer chromatographic method. The fungal colonies were transferred into Yeast Extract Sucrose (YES) Agar and incubated for 7 days at 25ºC for the production of secondary metabolites. Five microliter amounts of mycotoxin standard solutions (aflatoxin B1, B2, G1 and G2, and ochratoxin and the samples in YES medium were spotted and developed for a distance of 15 cm in a toluene-ethyl acetate-formic acid (60+40+0.5) system. The plates were inspected under longwave ultraviolet light. The samples with spots that matched R_f values of standard spots were submitted for conformation and quantization procedures.

2. Results and Conclusions

Total mold count ranged from $7x10^2$ to $3.3x\ 10^4$ cfu $g^{-1}$for the three kinds of hazelnut samples. The in-shell nuts were the most contaminated samples and kernels the least as shown in Table 1.

Penicillium was the predominant genus isolated from all three kinds of the samples. *Alternaria* and *Cladosporium spp*. also were prevalent in the three different samples. However, *Aspergillus* genus, especially *A. flavus*, as the dominant fungi isolated from nuts and oil seeds and the primary producer of aflatoxin, was not found in our samples. It has been reported that relative humidity of the environment and moisture content of the crop can be significantly correlated with *A. flavus.*

The results of the multi-toxin thin-layer chromatographic analyses revealed that that all tested samples were mycotoxin free, although several species of toxingenic fungi were recorded in all three types of samples. These results were in agreement with those of previous reports that there was no relation between presence of toxinogenic molds and mycotoxin contamination. The presence of toxinogenic molds only indicates a potential risk of toxin formation. On the other hand, the absence of toxinogenic molds also does not guarantee materials are free of mycotoxin (Bullerman, 1986).

In conclusion, higher total mold amounts for the in-shell nuts compared to the other two kinds of samples were the result of more mold contamination on the exterior surface of the shell during growth, harvest, and post-harvest operation and storage. In spite of the presence of toxinigenic molds in all three kinds of hazelnut samples, no mycotoxins were detected in the samples. Preventative strategies, including harvesting with minimal damage to shells, storing in highly air permeable sacks, mechanical drying, and storing at cool and dry conditions, are recommended to exclude or reduce toxigenic mold growth and toxin production.

Dr. Hanna provided the overall direction for this project, while. Dr. Xu was responsible for conducting the research to accomplish the stated objectives, with the assistance of Dr. Andreia Bianchini.

Goals and Outcomes Achieved

The long-term goal of this project was to explore the value-added opportunities for food and industrial applications and to accelerate the development and commercialization of hybrid hazelnut production in Nebraska. In this project, our investigation of total mold amounts, mycoflora species and potential mycotoxin contaminations in Nebraska hybrid hazelnuts are an integral part and play very critical and important roles in achieving long-term outcome measures for the project. With the information on mycoflora species and mycotoxin contamination obtained from this project, developing protective strategies to minimize mycotoxin contamination, and, therefore, improving the safety of Nebraska hybrid hazelnut during processing and storage, is on the way.

Beneficiaries

First, over 100 Nebraska specialty nut crop producers, food processors, nut traders will benefit from reading about the results through reports presented on the Industrial Agricultural Products Center web site (agproducts.unl.edu) and poster presentation/handouts at events typically attended by the specialty nut industry.

Further, a manuscript will be published in a peer-reviewed journal. It also will be presented at an international meeting. Therefore, the whole scientific community which works on tree nuts and hazelnuts will be impacted.

Lessons Learned

Summarized in the above paragraphs.

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Additional Information

A manuscript is in preparation and will be submitted for publication in the Journal of Food Science.

Other publications related Nebraska hybrid hazelnuts are:

1. Xu, Y.X., Bianchini, A., and Hanna, M.A. 2010. Identification of mycoflora species and mycotoxin contaminations in Nebraska hybrid hazelnuts. (In preparation).
2. Xu, Y.X., Hanna, M.A. 2010. Hanna, M.A. 2010. Nutritional and anti-nutritional compositions of defatted Nebraska hybrid hazelnut meal (In preparation).
3. Xu, Y.X. Hanna, M.A. 2010. Nutritional quality and oxidative stability of oil extracted from hybrid hazelnuts. International of *Journal of Food Science and Technology* (In press)
4. Xu, Y.X., Hanna, M.A. 2010. Evaluation of Nebraska hybrid hazelnuts: nut and kernel characteristics, proximate, oil and protein compositions. *Industrial Crop sand Product* 31(1): 84-91.
5. Xu, Y.X., Hanna, M.A. 2009. Synthesis and characterization of hazelnut oil-based biodiesel. *Industrial Crops and Products* 29: 473-479.

6. Xu, Y.X., Hanna, M.A., and Josiah, S.J. 2007. Hybrid hazelnut oil characteristics and its potential oleochemcial application. *Industrial Crops and Products* 26: 69-76.

Reference

Bullerman LB. 1986. Mycotoxin and food safety. Food Technology 40: 59-66.

Table 1. Total mold counts in each dilution concentration.

	Colony								
sample	10^{-2}		10^{-3}		10^{-4}		10^{-5}		**Counts**
	Rep .1	Rep. 2	Rep .1	Rep.2	Rep.1	Rep.2	Rep.1	Rep.2	
In-shell 1	TNTC	TNTC	42	33	2	0	0	0	
In-shell 2	TNTC	TNTC	25	31	2	5	0	0	
Average	**TNTC**		**32.75**		**2.25**		**0**		**$3.3x10^4$**
Kernel 1	12	11	1	1	1	4	0	0	
Kernel 2	4	1	1	1	0	0	0	0	
Average	**7**		**1**		**1.25**		**0**		**$7x10^2$**
Meal 1	7	9	1	0	0	0	0	0	
Meal 2	11	20	1	0	0	0	0	0	
Average	**11.75**		**0.5**		**0**		**0**		**$1.2x10^3$**

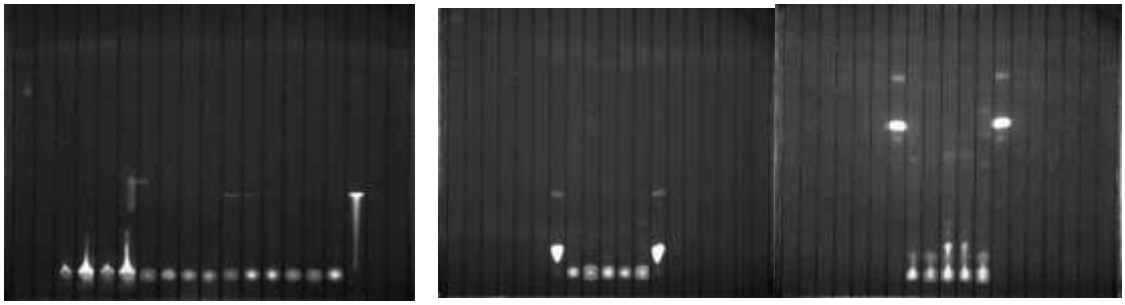
TNTC stands for too numerous to count

Figure 1 Total molds growing in different kinds (nut, kernel, and meal)

Figure 2. Three-point inoculation of fungal species isolating on growth media

(a) (b)

Figure 3. Microscopic morphologies of (a) Penicillum and (b) alternaria



(a) (b)

(c)

Figure 4. Multi-toxin thin-layer chromatograms for mycotoxins (a) screening in a toluene-ethyl acetate-formic acid (60+40+0.5) system; (b) confirming in a toluene-ethyl acetate-formic acid (5+4+1) system; and (c) confirming in a hexane-ethyl acetate-acetic acid (18+3+1).